PROCEEDINGS

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American Railway Engineering Association

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BUSINESS SESSION

PROCEEDINGS

The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways. Its action is not binding upon its members.

TUESDAY, MARCH 6, 1928

MORNING SESSION

The Twenty-Ninth Annual Convention of the American Railway Engineering Association was called to order in the Grand Ball Room of the Palmer House, Chicago, Illinois, by President D. J. Brumley, Chief Engineer, Chicago Terminal Improvements, Illinois Central Railroad.

The President:—The meeting will please come to order.

The Twenty-Ninth Annual Convention of the American Railway Engineering Association is now declared open for the transaction of business. This meeting is also the annual session of the Construction and Maintenance Section and of the Electrical Section of Division IV—Engineering, American Railway Association, the meetings being concurrent.

The first order of business is the reading of the Minutes of the last annual meeting. Inasmuch as these Minutes have been printed and a copy furnished to each member, the reading of the Minutes will be dispensed with, unless there is objection. There being no objection, the Minutes stand approved as printed.

The next order of business is the President's address. I found when I accepted the position of President of the American Railway Engineering Association that I had just two things to do. One was to do a year's work assisting you in whatever way I could, in preparing the reports for presentation at this meeting. The other obligation is one imposed by the Constitution in that the President is required to prepare and deliver an annual address. The work which you have done is represented in the Bulletins you have had for some time. The work I have attempted to do I am now going to read to you.

ADDRESS OF PRESIDENT D. J. BRUMLEY

Fellow-Members of the American Railway Engineering Association, and Guests:

INTRODUCTION

The success attending the work of your Association this year represents the co-operative and cumulative effort of the whole membership. Your President has no means other than the assistance of the members of the Board of Direction to guide you in the many phases of railway work embraced in the reports you now have ready to consider and act upon at this three-day meeting. It has been most gratifying to note the ready responses to requests made on the Committees to complete their year's work and file their formal reports within the time limit fixed.

The burden of the details of the year's work falls on the Secretary's office. It is here that your reports pass through the successive processes of editing in preparation for the printer, proofreading and final checking before publication. My observation, based on many visits there during the year, is that his office is working under peak load throughout the year. For you the year's work is concluded upon the adjournment of the second session of the third day of the annual meeting. For him, the work of the annual meeting continues until the Proceedings and Manual, or General Index, if any, are in the mails on the way to you. In addition to this work, Bulletins are issued monthly; Board of Direction and committee meetings arranged; committees notified of changes in assignment or personnel; membership and advertising accounts checked, and a multitude of demands made on his time daily. His intimate knowledge of the records, traditions and history of the Association, acquired through twenty-eight years' continuous service, and wide acquaintance with the membership, makes this accomplishment possible. Much of your successful year is due to your efficient Secretary, whose sole thought is to promote your best interests and to make the current administration of greater value to you than any preceding.

It has been a great pleasure to have served you and I take this opportunity to express my appreciation of your unstinted helpfulness and splendid co-operation.

The first annual meeting of your Association was held in Chicago twenty-eight years ago, following about two years of preliminary organization meetings, the formation of a Constitution, assignment of subjects for formal reports and selection of members of the then fourteen working committees. At that meeting there were gathered a group of earnest, far-visioned and determined men who were the recognized leaders and authorities on the principles and best practices pertaining to the scientific and economic location, construction, operation and maintenance of railways. The founders of the Association sought to create a continuing organization which would cover the entire field of railway engineering. They considered their first duty to be the investigation and report on a few of the fundamentals of railway engineering which were most pressing at the time and which gave promise of greatest benefit to their respective railways, leaving to future generations of Engineers the task of developing new subjects and of amending conclusions so as to keep pace with, or even anticipate, the development of the art. Some of the Charter Members who were present at that first meeting have attended all twenty-eight former annual conventions and are in attendance at the meeting this morning. The Proceedings of the earlier annual meetings bear evidence of the broadminded spirit and enduring patience manifested then, and it has continued through all the succeeding years of the Association's history. It is clear that individual ideas were fully and forcefully placed before the meetings, but there is no case on record where a common ground for adjustment of difference of opinion could not be found. They looked to the future of railway engineering and laid a foundation for the Association so comprehensive and all-enduring as to insure the continuance of this organization

as a potent factor in working out the problems of railway engineering economics. The structure they designed, the specifications for which were prepared with such meticulous precision, and which was first tried out twenty-nine years ago, has withstood the test of all these years of operation and has performed an invaluable service to railways. The standard they set for investigation, research, experimentation and sound conclusions has been maintained by the succeeding administrations which have reported to you at their annual conventions.

DECEASED MEMBERS

It is with profound regret that we note the depletion of our ranks by the death of thirty members during the year. One of them was a Past-President of the Association, two were Treasurers, four were Charter Members, and another was the President of a railway.

FINANCES

We have lived within our income and the Association's finances are sound. All current obligations have been met, leaving a balance of $262.25 to be added to the surplus. The cost of printing next year will be greater on account of re-issuing the Manual and publishing the General Index. This increase will be largely offset by the sale of the Manual. The surplus has been increased $9,720 during the past five years, resulting in a total accumulated surplus at the end of this year of $54,005.48. The present administration holds the view that the surplus should be kept intact, increased by future economical administrations and used at some later date in providing a permanent home for the Association's activities.

MEMBERSHIP

The qualifications for membership in this Association were made broad enough to admit to membership not only technically trained Civil, Mechanical and Electrical Engineers, but also officials of railways with not less than five years' experience in the location, construction, operation and maintenance of railways. It is indeed fortunate that this far-sighted provision was made. Many officers of railways not trained technically as Engineers have availed themselves of the opportunity to become members, thereby affording the material for the creation of an organization capable of dealing with the more technical problems of design and specifications and also of incorporating the practical application of engineering in the principles of recommended practice. The operation of this plan resulted in the technical man incorporating in his design the practices of field operation and the practical man appreciating more fully the basic principles of design. The practical training of the technical Engineer is usually through the various engineering grades on location and construction, followed by practical experience in responsible charge of maintenance and finally through various degrees of responsibility to the position of Chief Engineer. These years of training result in a developed product capable of attacking practical problems in the field or directing the more highly

technical problems in the office. The practical men have willingly accepted their share of the responsibility in the solution of these engineering questions and have contributed very largely to the splendid success of the Association. Thus the blending of the technical and practical has produced a resultant which gives a distinct and definite value to the work of your Association and enables it to develop into the broadest field of railway engineering endeavor.

There was not a concerted drive made for new members the past year, although no opportunity was allowed to pass to enlist the interest of capable men in the affairs of the Association. On the first of March this year there were 2607 members, an increase of 96 during the year. On the date of the first meeting there were 279 members; in 1904—453, 1908—723, 1912—1030, 1916—1336, 1920—1638, 1924—2148, and 1928—2607. The growth of membership in the past year is of the grade and type which can be relied upon to carry the work forward on the same high standard as that accomplished by the Association in the past.

COMMITTEE-WORK

The year's effort of the working committees is expressed in the Bulletins you have had in your possession for some weeks. The committees which were organized immediately upon the adjournment of the last annual meeting have worked with a fixed date as controlling in point of time and so organized themselves that the expectations of the Board of Direction could be realized. This spirit, as shown by the committees, is one of the dominant qualities of the membership in this voluntary Association and guarantees the continuance of the excellent reports submitted at the first annual meeting and insures the fulfillment of the hopes and ideals of the organizers. The quality and quantity of committee reports are in keeping with the records of the past. The working committees for the ensuing year have been organized and their work has been assigned, subject to such modifications as may be found necessary after the adjournment of this convention. Some of the re-organized committees have held meetings in December and others in January and February. By this new method, we have gained nearly three months on the new year's work. This will materially increase the working period, thereby giving more time for the consideration of reports and insure their completion before November 30th, this year. This is done for the express purpose of getting the reports in your hands at least two months in advance of the annual convention, thereby insuring you time enough to review them carefully and to prepare for constructive discussion when the reports are formally presented next March.

The Board of Direction is giving consideration to assignment of the subject of Sanitation to a working committee, the creation of a new committee to make a study of Rivers and Harbors, and the consolidation of Committee VII—Wooden Bridges and Trestles, with Committee XV—Iron and Steel Structures, if it should appear that the work of the Association will not suffer thereby.

TRANSVERSE FISSURES IN STEEL RAIL

Among the major subjects under investigation by the working committees is the development of a device for the detection of transverse fissures in steel rails. The location of fissure rail in service tracks has been under an exhaustive study by the Rail Committee for fifteen years. Detection of such rails by visual inspection was laborious, slow and uncertain unless the radial growth from the nucleus had extended to the contour of the rail section. The magnetic testing device originated by the Bureau of Standards, after exhaustive tests by two railroad companies and a steel company, was abandoned. The Rail Committee has been working for two years with the Sperry Development Company to perfect a device which employs the principle of air-gap resistance to the flow of electrical current to disclose the location and extent of transverse fissures. The laboratory tests, having demonstrated the feasibility and practical working of the device, authority was obtained from the American Railway Association to expend $23,306 on the development and building of a transverse fissure detector car. That unit is built and is now on the lines of the New York Central Railroad, undergoing preliminary tests and adjustment before final acceptance by the Rail Committee. A schedule for the lease of the car, at a stipulated daily rental, to a number of railroad companies, has been prepared by the Rail Committee, the idea being to demonstrate the use of the device in widely-separated sections of the country. However, to make an inspection of all the rails in the main tracks on the North American Continent will require the use of many machines, the number depending upon the frequency which such inspections are made. Further details will be given by the Rail Committee at this annual meeting in a supplemental report.

PUBLICATIONS

In addition to the publication of the Bulletins containing reports of standing committees, some of them contain monographs on timely subjects, one issue being devoted to the Mississippi Valley flood. The Proceedings for 1927 were delivered to you last August and the revised Manual is now in process of printing and will be ready for distribution early this year. The subjects selected for investigation and report contain current railway engineering problems which are of vital interest to the whole membership of the Association. It is the aim of the Committee on Personnel of the Board of Direction to assign members to working committees who are specialists in their particular line. This selection is made to combine the study of special committee assignment with problems the members meet in their daily routine work. To serve on a working committee gives the assigned member an opportunity of pursuing an elective post-graduate course in railway engineering and also of preparing a thesis on his special phase of railway engineering problems. Frequently the reports of committees are the result of a study of a particularly urgent problem which a railway faces and is of general interest to the railways as a whole. In the preparation of committee reports they are viewed from every angle by the members of the committee and many of the reports have the benefit

of collaboration with another interested committee. Finally these reports are brought before the annual convention where they are subjected to a critical review of the entire Association membership. The manner of selecting subjects for reports, the selection of men to serve on committees, the methods used in carrying out investigations and the processes observed for adopting principles of recommended practice all tend to establish a high value on your publications. Indeed, the publications of your Association have become the current textbooks not only in Engineering Colleges and Universities, but also on construction and maintenance and are so recognized by railway men in this country and abroad. They have been translated into foreign languages and issued as public documents by several foreign governments.

FEDERAL VALUATION

It is of interest to note that the Federal valuation work, begun in 1913, is approaching the completion of its primary phase. Tentative valuations have been served on all carriers subject to provisions of the Valuation Act. Hearings are concluded on 70 per cent of the protests and if the present rate is maintained all of the cases should be before the Interstate Commerce Commission early next year. It is proposed to bring the valuation to date and recommendations to accomplish this are before Congress. It is assumed that this work can be completed by 1931, at a cost of $7,500,000 to the Government, after which time the cost of maintaining a current valuation would be $500,000 annually. Conferences on working out the plans and methods for bringing the valuations to date are in progress between representatives of the Bureau and the carriers. Valuation work to those carriers subject to recapture under the provisions of the Transportation Act of 1920, has developed into a problem of first importance as the total payments made by the carriers on account of recapture to the end of last year amounted to approximately $8,000,000. The administration of Valuation Order No. 3, covering the accounting for additions, betterments and retirements, valuations to be established in recapture cases, and the accounting regulations under provisions of the proposed Depreciation Order 15100, all have an intimate and a vital bearing on engineering estimates, analyses and economic studies. The railway engineering problems that now confront you include not only the fundamentals of pure engineering principles of a generation ago but deal also with accounting, valuation, law and related subjects.

NEW RAILWAY PROJECTS

Several railway construction projects are worthy of reference. The Great Northern Railway is driving a tunnel 7.77 miles in length through the Cascade Mountain Range. The pioneer section is nearly through, with less than one-half the total length to be enlarged. Notwithstanding the difficulties in controlling the intercepted water, the enlarging and lining is proceeding at such a rate as to insure the completion of the project and have it ready for traffic the latter part of this year. The Moffat Tunnel, six miles in length, through the Continental Divide in Colorado, is com-

pleted and was officially opened for operation at noon February 26th last. This tunnel route will shorten the distance over the Divide twenty-seven miles and the road when completed to Salt Lake City will reduce the distance between Denver and the Pacific Coast 181 miles. The Edgewood Cutoff of the Illinois Central Railroad System, extending from Edgewood, Illinois, via Paducah, to Fulton, Kentucky, is nearing completion and will be put in operation this year. Its completion will give a through north and south route twenty-two miles shorter than the present one, and a 0.3 per cent grade line for traffic which was formerly handled on a 0.8 per cent grade. Three terminal projects of more than ordinary interest are in progress. In Cleveland, Ohio, a passenger terminal, near the public square, is under construction, to care for the through passenger needs of the New York Central, Big Four and Nickel Plate Railways, and also the Rapid Transit System serving the city and the shoreline suburbs. This project, in addition to creating the many facilities required for a passenger terminal, includes an office building fifty-two stories high. In Philadelphia the Pennsylvania Railroad Company has planned and has started construction work on a station at West Philadelphia to replace the Broad Street Station. The project includes not only through passenger station facilities but also the electrification of the present steam operated suburban lines, a subway from Broad Street across the Schuylkill River for the present elevated lines, a new office building, opening of streets and rearrangement of yards and related facilities. In the vicinity of Chicago the Chicago & Northwestern Railway has begun the construction of an L-shaped transfer freight station, the house to cover about twenty acres, and the entire project, including two classification yards, engine terminals and other facilities, about fifteen hundred acres.

CENTENARY EXHIBITION

The year 1927 marked the completion of the first century of rail transportation in the United States. February 28th, 1827, the State of Maryland issued a charter for building a railroad from the City of Baltimore to the western terminus on the Ohio River. History records that the first construction work of this new enterprise was started July 24th, 1828, and the completed track reached the east bank of the Ohio River January 1st, 1853. The construction of three hundred miles of railway to-day across the Appalachian Mountains, in the light of one hundred years' experience, is a considerable task. To those pioneers who were compelled to originate and develop engineering practice, standards for roadbed, track structure, buildings, bridges, equipment, and construction methods, the time spent in this first construction must have seemed long but to those who review it now in the light of all the facts, it was a most remarkable performance. The colleges at that time were not training men as Engineers. West Point was the only one in the country which offered a training equipping men with the elementary mathematics required for railway engineering work. The work of these pioneer Engineers was well done. The Carrollton Viaduct, a stone arch bridge, the longest span 80 feet in length and 65

feet in height, has stood the test of a century, and to-day without any evidence of inadequacy, carries 325-ton locomotives at schedule speed. Wendell Bollman and Albert Fink, while in the service of this pioneer road, designed their respective types of permanent metal bridges to take the place of wooden Howe trusses. The story of the Centenary Exhibition, "The Fair of the Iron Horse," held at Halethorpe Field near Baltimore, Maryland, last year, will be told in moving pictures to be shown this evening.

FLOODS OF 1927

Two sections of the United States were visited by the most disastrous floods known—one which embraced the valley of the Mississippi River and its tributaries, and the other the States of New York, Vermont, New Hampshire, Connecticut and Massachusetts. The New England disaster of November, 1927, was caused by an unprecedented rainfall of three days in a territory whose topography was such as to induce a rapid runoff into the narrow valleys, resulting in higher stream stages than had ever been recorded. The volume of the discharge was many times the capacity of the bridge structures spanning the streams. Tracks were thrown from the roadbed, and bridges and buildings on the low ground were carried along with the crest of the flood. The work of restoration in many places involved a complete reconstruction under most trying conditions. The railways suffered very heavy losses and at this time those most severely damaged are just getting their lines back to normal service.

The floods of the Mississippi River are recurring events. In the forty-five years since 1882 this stream has exceeded the flood stage twenty-eight times. During the year 1927 the gage reading at all Government stations, except New Orleans on the main stream, showed greater heights than ever before observed. The flooded area, about 18,000 square miles, rendered inoperative approximately three thousand miles of railway for periods ranging from ten to one hundred and twenty days. The direct property loss to the railways was, in round figures, $20,000,000. It is estimated that 600,000 people were driven from their homes and the total property damage in the submerged area exceeded $300,000,000. The authorities of the states on the lower course of the stream and Federal commissions have co-operated for many years in designing and building levees and other protective works to confine the waters to a defined channel. Further protective measures are now under consideration by Government Engineers whose reports are before Congress. Your Board of Direction, at a meeting last June, authorized the creation of a Special Committee on the Mississippi River Flood for the purpose of collecting information available to the railways and presenting it to the Association membership and the House Committee of Congress. On account of the urgency of getting the data, although incomplete, before the House Committee of Congress, the earliest information was published in Bulletin 297, issued last July. This proved of so much value to the House Committee, that the information was revised to a later date and published as Bulletin 303, Part 2, January this year. This disaster created a real opportunity for your Association to compile and

place the facts of the flood, respecting the railways in the Mississippi Valley, before Congress. Much credit is due the able Chairman and members of the Special Committee for the great amount of effort and time required to compile the data and complete the report.

Your Association members representing railways whose properties were involved in these disastrous floods were instrumental in organizing the necessary forces of men and assembling materials and equipment, first to save the marooned inhabitants, and second, to restore the damaged railroad property to an operating condition after the flood waters had sufficiently subsided. Some of you gave personal direction to the enormous task and remained at the front until the job was completed. It is fitting and appropriate that your Association should give recognition to the courage and resourcefulness of those of you who served the engineering profession so notably under such adverse conditions. The manner of doing this is fully covered in the Secretary's report. Some phases of the Mississippi Valley Flood will be illustrated in the moving pictures to be shown here this evening.

TRANSPORTATION

Transportation, at present, may be classified as highway, water, rail and air. All of these means are indispensable agencies of the present-day civilization and each performs its special function. The highway has served in its diversified forms from the earliest days of man's history and in recent years, by reason of the construction of permanently hard-surfaced roads, has become an important factor in shorthaul freight and passenger business. It will continue to serve this useful purpose and will reach its peak when the density of this class of traffic is equivalent to the capacity of available highways. Water transport will also serve in its special field of usefulness on naturally navigable open waters. In countries such as those on the North American Continent, the deepening of rivers not lying directly in the general line of traffic and canals across country where differences of elevation are great and where seasonal navigation must be observed, will serve a restricted purpose. Air transport is still in its infancy and must pass through that period of experimentation and development which attended the evolution of the railways. It has found a place in transporting mail, passengers and parcel freight between widely separated points where elapsed time and not cost of transportation is controlling. We are frequently reminded of the endurance tests made with heavier-than-air machines and were thrilled last June when one of our fellow American Engineers, who navigated the air between America and Europe and whose thirty-six hours of endurance flight landed "We" at the French Flying Field, Le Bourget, Paris, France. Regardless of other transport agencies, the railways will continue to handle the major part of our transportation service. The existing lines of railways have resulted from the demands for transport service. The communities they now serve will continue to grow, thereby requiring the expenditure of large sums for improvements to maintain, improve and enlarge the present service. Freight loading increased from 583,000,000 tons in 1900 to 1,363,000,000 tons in 1920 or

133 per cent in twenty years. Passenger trains are pulled at higher rates of speed by locomotives with much greater wheel loads. If the next score of years shows a continuance of the increase in freight loading and speeds, there will need to be large sums expended to keep capacity of rail lines in step with traffic. The burden of providing a suitable and adequate instrument for meeting the future needs of railway transportation rests with the members of this Association, the scientists and the manufacturers interested in improving this form of transportation service.

FUTURE WORK

A review of the work done by your Association in the past twenty-nine years invites some speculation as to its work for the succeeding generation of Engineers. It is clear that the need for new rail lines and extensions is almost satisfied and it would appear that the work for the immediate future would be the orderly development of rail lines in existence. The railways are susceptible of great improvements, such as reduction of grades, multiple tracking, elimination of curvature, construction of diversion lines around congested centers, shortening of lines and the extension and use of block signals. It will be found that where property values are high and the acquisition of additional land is prohibitive, double-decking, and probably triple-decking of railway facilities will be found economical. Such improvements will, however, be quite costly and will not be undertaken unless the analyses of savings in operating costs to be offset by interest on additional investment will show resultant economy. Electrification no doubt will be extended, since it has great operating advantages over steam under given conditions, such as density of traffic, heavy grades, feasibility of operation in congested terminals, a commutation service where frequent stops are made and operation under covered areas where air-right developments are justified. The steam locomotive, or some other form of self-contained unit, for many purposes has operating advantages, and the immediate future, at least, has many possibilities for its improvement and the development of internal-combustion and storage-battery locomotives. The growth of urban communities has consistently followed the establishment of rail transportation lines. The rail line which was once at the outer edge of the municipality is now in the congested center of the city. The terminal facilities which amply supplied the transportation needs a generation ago, must be moved farther away where there is available space unrestricted by highways.

The railway terminal problem in a great city is one requiring long experience in railway engineering, resourcefulness of design, a broad conception of civic requirements, and great patience in dealing with legislative and regulatory bodies whose representatives are not familiar with the necessities of railway transportation. The Engineers of certain railways centering in this city have one of the most intricate and complex problems to work out. Three groups of railways have passenger terminals at the southerly end of the loop section, on both sides of the winding Chicago River. The river is to be straightened to permit of opening streets across

these terminals and thereby create street traffic flow channels east and west and north and south. The work of straightening the Chicago River, which is to be started this year, is of outstanding magnitude, involving as it does about one-half the through passenger and much of the local freight traffic to and from the city, the water transportation on the river and the street traffic where it impinges on the area. It is a project whose conception cannot be expressed on one sheet of a drawing and one which will require volumes of plans and specifications to make clear the details, and one giving the Engineer an opportunity of doing a real job in his characteristically thorough manner. Members of this Association have done some of this work in the past, but much of the work in the future will deal with problems more concerned with economic phases and betterment of existing lines rather than the construction of railroads into unoccupied territory.

PROPOSED CHANGE IN CONVENTION PROCEDURE

At the last meeting of the Association, under "New Business," the following motion was made by Mr. L. A. Downs and adopted:

"In the interest of orderly procedure of our Association, of which I am a strong advocate, I rise to make a motion. The opening day of our meeting we had a Committee, the Committee on Records and Accounts, that left their usual work for the year and came forward with a new plan of procedure for the Association. I believe any member of this Association has a perfect right at any time, in an orderly way, to make suggestions for the betterment of the Association, and I think that any group of men, as was done in this case, even though they were out of order in doing so, should be given some consideration. I therefore wish to make a motion that the Board of Direction give consideration to the suggestions that this Committee made."

The Board of Direction, through a committee appointed for this express purpose, has made a study of the points on convention procedure questioned by the Committee on Records and Accounts. This Board Committee, through contact with the working committees and by replies to a questionnaire addressed to the entire membership, has obtained a representative cross-section of your views. The alleged deficiencies may be classified as:

	Yes *Per Cent*	*No* *Per Cent*
1. Sectional meetings	6.25	93.75
2. Lack of discussion	60.00	40.00
3. Elimination or curtailment of progress reports	29.50	70.50
4. Four-day versus three-day convention period.	23.77	76.23

Since the Board Committee's report will be distributed during the morning session of the third day of this meeting, I will briefly summarize the general trend of the replies to the questionnaire:

1. Sectional Meetings

The Association has only one purpose "the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways."

Would tend to split up Association.

Many members attend the convention to meet others engaged in railway work, listening to or participating in discussions on all subjects.

Committee meetings are virtually sectional meetings where there is no restriction on discussion.

No procedure is good that will prevent everyone from hearing reports on all subjects, and would reduce the educational value of the Association.

The American Railway Engineering Association represents one branch of railway service—Railway Engineering.

It differs from the A.S.C.E. and the A.S.T.M. and the same reason does not apply for further subdivisions:

In fact, it is a distinct reason for not carrying out the sectional meeting plan.

2. Lack of Discussion

Caused by late committee reports.

This defect was corrected this year.

The last Bulletin was mailed you on February 7th.

The reports submitted in the early years of the Association contained subjects which were familiar to nearly all the members present.

These elementary subjects settled, the Association next dealt with questions relating to specialized and technical subjects.

Members not specializing on certain subjects will not criticize reports.

Discussion needed if committees have gone astray.

We now have better and more scientific discussion than other engineering organizations.

Can be remedied by preparation in advance to discuss reports.

Good reports warrant little discussion.

Immature reports will cause discussion.

Differences are adjusted by committees while report is in course of preparation.

Written discussion prepared by members will eliminate aimless and irrelevant discussion.

3. Elimination or Curtailment of Progress Reports

Amount of detail depends on progress committee has made.

Details are necessary to grasp the full value of included material.

Many committees work by progress reports which are as important as the final report.

Need not be in detail but salient features should be pointed out to draw out members' views and develop suggestions.

Curtailment would withhold valuable information from interested members and would not help the situation.

Detract from interest of members on committees, and would result in indifferent committee work.

Present practice is satisfactory.

4. Three-Day Versus Four-Day Sessions

Cannot hold interest of members more than three days.

By proper organization and preparation of members, the business can be transacted in three days.

Four-day sessions would not increase interest but would increase the number leaving before the end of the convention.

Four days too long—three enough.

If time is too short, hold an evening session.

Not required now—will work out when extra day is needed.

Regardless of value of extra day, members cannot spare the time.

Manual

Committee on Records and Accounts also suggested that the work of evolving a new and comprehensive Manual be undertaken by a staff of paid full-time experts at Association headquarters. The Manual results from investigations, studies, reports and conclusions of the working committees composed of experts along their particular lines. To become effective, their conclusions must be approved by the Association. To carry out the suggestion of the Committee on Records and Accounts is contrary to the principles on which this Association has successfully operated for twenty-nine years under the present method. The suggested Manual Committee could not perform any greater service for the Association than is now done by each of the working committees and the Secretary.

To my personal knowledge the issues suggested by the resolutions referred to have been continuously before your Board of Direction for at least six years. Your Board has insisted (and your response was always whole-hearted) that subjects should be fully developed, well thought-out and matured before being presented for adoption as recommended practice. Reports prepared under such limitations have resulted in apparent lack of constructive discussion at the time of presentation for adoption. However, some consideration should be given to the exhaustive discussions had by the committee when a report is being prepared. The committees have been enlarged from year to year to make them more representative of the differing conditions obtaining on many railways and thereby insure more complete and comprehensive reports. These methods have largely contributed to less constructive discussion at the annual meetings. It would seem that this condition is not a serious shortcoming but rather a healthful indication that the Association is making real progress along logical lines. The earlier publication of committee reports, the reorganization of the committees and assignment of work on December 1st each year, and the continuance of committee work during the winter season will in a large measure remedy the faults complained of as to this phase of convention procedure.

It is to be noted that your views as expressed by the replies to the questionnaire are not to go to the sectional meeting plan, neither to eliminate nor curtail progress reports, nor adopt the four-day convention plan. After an exhaustive study of the material you supplied for the determination of these most involved problems, your Board of Direction has reached the conclusion that no changes, other than the corrective measures already taken, are necessary at this time.

IN CONCLUSION

The achievements of your Association thus far in its history have exceeded the fondest hopes of those most intimately associated with its early history. The influence of its committee-work, conventions, Proceedings, Manual and other publications, have furnished the post-graduate work for those technically trained and broadened the field of the practical men in our ranks. As time goes on your Association will continue in the work so well

started, and as in the past, will increase its committees and broaden its scope to meet the changing conditions in the field of railway engineering activities. Your Association by its work is meeting the railway engineering problems of today and is laying the foundation for future work as well. What you are doing for your successors is appropriately expressed by the words of the poet:

An old man, traveling a lone highway,
Came at the evening, cold and gray,
To a chasm vast and deep and wide.
The old man crossed in the twilight dim,
For the sullen stream held no fears for him,
But he turned when he reached the other side
And builded a bridge to span the tide.

"Old man," cried a fellow-pilgrim near;
"You are wasting your strength with building here.
Your journey will end with the ending day
And you never again will pass this way.
You have crossed the chasm deep and wide,
Why build you this bridge at eventide?"

And the builder raised his old gray head,
"Good friend, on the path I have come," he said,
"There followeth after me today
A youth whose feet will pass this way.
This stream, which has been as naught to me,
To that fair-haired boy may a pitfall be.
He, too, must cross in the twilight dim,
Good friend, I am building this bridge for him."

And so we find this Association at the beginning of its thirtieth year, with a long line of accomplishments and a fixed place in railway transportation endeavor, yet ever seeking for improvement in processes, purposes and organization, regarding nothing as final and laid by, ready to appraise, willing to change and daring to hope for continuing progress. (Applause.)

The President:—The next order of business is the reports of the Secretary and Treasurer.

Secretary E. H. Fritch:—The reports of the Secretary and Treasurer have been in your hands for some time, and you may have had opportunity to look them over, and therefore it is unnecessary to read them in detail.

The reports give a brief summary of the activities of your Association during the past year. Under five general headings are grouped information on the major activities, publications, membership, finances and miscellaneous items. The reports are therefore offered for your approval.

REPORT OF THE SECRETARY

March 1, 1928.

To the Members:

This annual report gives in condensed form reference to the important activities of the Association in 1927, under the presidency of D. J. Brumley, grouped under the following headings:

(I) PRINCIPAL ACTIVITIES

a Introductory
b List of Committees
c Committee-work in 1927
d Personnel of Committees by Railways
e Relations with Other Organizations

(II) PUBLICATIONS

a The Bulletin
b The Proceedings
c The Manual
d The General Index
e Monographs

(III) MEMBERSHIP

a Status of Membership
b Increase in Membership
c Benefits of Membership
d Classification of Membership
e Deceased Members
f Geographical Distribution

(IV) FINANCES

a Summary of Receipts and Expenditures
b Stresses in Track Fund
c Report of the Treasurer

(V) MISCELLANEOUS

a Changes in Board of Direction
b Transverse Fissure Detector Car
c Use made of A.R.E.A. Recommended Practice
d Historical Note
e Token of Appreciation

Respectfully submitted,

E. H. Fritch,

Secretary.

(I) PRINCIPAL ACTIVITIES

INTRODUCTORY

The past achievements of the Association have fully demonstrated the wisdom of its founders in providing that its activities be carried on through the medium of Standing and Special Committees. At the time of the formation of the Association, the field to be covered—the Engineering Department of railways—was divided into fourteen sub-divisions, and a committee appointed for each division.

The developments in railway service in subsequent years made it necessary and desirable to enlarge the scope of the Association, and to create additional committees to meet the newer problems and even to anticipate requirements. At the present time there are twenty-three Standing and three Special Committees. The following table is a list of the present committees, the titles indicating their functions:

Title of Committee		*No. Members*
I.	Roadway	26
II.	Ballast	25
III.	Ties	29
IV.	Rail	31
V.	Track	38
VI.	Buildings	21
VII.	Wooden Bridges and Trestles	31
VIII.	Masonry	26
IX.	Grade Crossings	37
X.	Signals and Interlocking	20
XI.	Records and Accounts	28
XII.	Rules and Organization	22
XIII.	Water Service	36
XIV.	Yards and Terminals	39
XV.	Iron and Steel Structures	35
XVI.	Economics of Railway Location	29
XVII.	Wood Preservation	27
XVIII.	Electricity	23
XX.	Uniform General Contract Forms	23
XXI.	Economics of Railway Operation	37
XXII.	Economics of Railway Labor	26
XXIII.	Shops and Locomotive Terminals	31
XXIV.	Cooperative Relations with Universities	18
Special.	Stresses in Railroad Track	19
Special.	Standardization	26
Special.	Clearances	12
		715

COMMITTEE-WORK IN 1927

The committees are made up of experienced, scientifically-trained men, selected for their special abilities along certain lines. In the solution of problems assigned them for study and report, these earnest men are actuated by a sincere purpose to arrive at what they consider the best practice for the railways to follow. The benefits of their deliberations are passed on to those having need for this authoritative information in their daily work.

The Standing and Special Committees have given an account of their activities during 1927 in the reports published in Bulletins 300 to 304, inclusive (for October, November, December, January and February).

The following is a resumé of the important subjects reported on by the respective committees.

Report of Committee on Standardization.....Bulletin 300

W. C. Cushing, *Chairman*

"Why is a Committee?" forms an interesting Foreword to the report. Following a discussion of the general subject of "standardization" and "simplification," the report contains the result of a canvass made by chairmen of the various committees as to the extent of use of the A. R. E. A. "recommended practice" on the roads with which the members are connected. The affiliation with American Engineering Standards Committee is explained, and a list of projects on which the Association is collaborating is given. "Thoughts on Standardization," by W. C. Cushing, Chairman of the Committee, is a general review of the work of standardization.

Report of Committee on Uniform Contract Forms.....Bulletin 300

J. C. Irwin, *Chairman*

A revision of the "Form of Agreement for Interlocking Plant" is the result of joint study with the Signal Section, American Railway Association. Revision of the "Form of Agreement for Industry Track" is the result of co-operation with various interests concerned, notably the American Petroleum Institute. "Form of Agreement for Joint Use of Freight Terminal Facilities" is offered for approval; "Form of Cost-Plus Percentage Construction Contract" is submitted for discussion.

Report of Committee on Water Service.....Bulletin 300

C. R. Knowles, *Chairman*

Drinking water conditions on railways during the Mississippi Flood of 1927 are described. Pitting and corrosion of boiler tubes and sheets is covered by two individual contributions entitled "Causes of Boiler Pitting and Means of Prevention in Neutral and Alkaline Waters" and "Prevention of Pitting and Corrosion by Electro-Chemical Polarization." The use of sodium aluminate on the Rock Island Lines forms an interesting monograph. Foaming of locomotive boilers, with special reference to the influence of suspended matter on foaming and cost of blowdown, is treated comprehensively; the "Cost of Blowdown of Locomotive Boilers" is an interesting addenda to this subject. Carbonate and sulphate waters, their relative influence on the operation and maintenance of boilers and their comparative costs of purification substantiates the conclusions of the Committee of 1914 that 7 cents at that time (equivalent to 13 cents at the present time) is a fair measure of the cost of repairs and extra fuel resultant from the scale deposited in locomotive boilers. Types of hydrants for coach yards and general service, and methods for supplying water to coaches are dealt with and a number of typical installations are illustrated. Pipe for service lines three inches and under in size, with particular reference to the use of prepared joint cast iron pipe and copper and brass pipe as substitutes for steel and wrought iron pipe, are treated exhaustively. Disposal of sludge at water softening plants is one of the problems with which railways operating lime and soda-ash softening plants have to contend. The methods used are described and a layout of a sludge basin given. The economical spacing of water stations in connection with increasing capacity of engine tenders is a valuable contribution to the information on this subject.

Report of Committee on Ties.....Bulletin 301

W. J. Burton, *Chairman*

The results of tests made in the laboratory of the Pennsylvania Railroad at Altoona on various forms of anti-splitting devices form the basis of a report on this subject. On the subject of sizes of holes for pre-boring for track spikes, report is made on the result of tests made by the Atchison, Topeka & Santa Fe Railway. The tests were made to determine the holding power of spikes in various wood species, both treated and untreated. On the subject of renewal of switch ties, the Committee concludes that in general the individual method of renewing switch ties is the best economically, and preferable from a safety standpoint. For the past ten years the Committee has annually reported on the use of substitute ties; the current report brings this data up to date. The Committee has developed a traffic unit for use in comparing cross-tie life.

Report of Committee on Electricity (Electrical Section)....Bulletin 301

E. B. Katte, *Chairman;* Sidney Withington, *Vice-Chairman*

The developments in water power in this country and Canada are given in detail and reference made to new projects contemplated. The present status of the revision of the National Electrical Safety Code is given. A preliminary draft of a Specification for Catenary Construction for Railroad Use is submitted. Approval of the report of the Department of Commerce on one-piece porcelain insulators, in the interest of elimination of waste, is recommended. Following the practice of previous years, data in regard to third-rail clearance and overhead clearance are given. On the subject of specifications for track and third-rail bonds, the report deals with specifications for measurement of bond resistance; current carrying capacity of bonds; details of bond design; effect of heat of welded bonds on track rails, and means of attaching bonds to manganese track rails. A revision of the Incandescent Lamp Schedule is submitted. A progress report on flood lighting of railway yards is offered. A comprehensive report on the design of indoor and outdoor substations is submitted as a progress report.

Report of Committee on Ballast.....Bulletin 301

Paul Hamilton, *Chairman*

The report presents the result of an investigation as to the use by railways of the ballast sections and specifications for ballast recommended by the Association; the conclusions of the Committee are that no changes in the sections or specifications be made at this time. The Committee is studying the comparative values of various ballast materials, with special reference to drainage and effect on costs for track maintenance, in collaboration with the Roadway Committee. The causes and effect of pumping joints on railway track and the excess cost of maintenance resulting therefrom is reported on. A report of progress is presented on the subject of Shrinkage of Ballast Materials.

Report of Committee on Shops and Locomotive Terminals.Bulletin 301

F. E. Morrow, *Chairman*

Presents a valuable report on Locomotive Coaling Stations, including recommendations as to location, track layouts, storage bins, hoisting capacity, scales, housing, electrical work; also a typical specification for a mechanical type of coaling station; a number of installations are illustrated. Methods for the safe and convenient storage of crude and fuel oils are interestingly described and illustrated.

Report of Committee on Iron and Steel Structures.....Bulletin 301

B. R. Leffler, *Chairman*

A revision of the article on "Workmanship," in the General Specifications for Steel Railway Bridges, is offered as information. The present and proposed versions are set forth in parallel columns. The Committee is collaborating with the Association of State Highway Engineers in the drafting of a Specification for Steel Highway Bridges; is also co-operating with a committee of the A. S. C. E. on column tests. An investigation on the bearing values of large rollers under the auspices of the Committee is being carried on at the University of Illinois. Progress is reported on the investigation of copper-bearing steel for structural purposes.

Report of Committee on Yards and Terminals.....Bulletin 302

J. E. Armstrong, *Chairman*

Recommendations are made that "gradients for ramps in passenger stations preferably should not exceed 10 per cent; that the gradient of 7 per cent is the steepest yet used to any extent for trucking ramps; that the minimum weighing time in motion weighing of cars on track scales be fixed at four seconds." The report contains an exhaustive study of the co-ordination of steam railway and motor bus transportation facilities; a typical example is cited in the case of the bus terminal at Boston. A suggested arrangement of units and description of operation for a generalized type of a classification yard is reported in detail, including plan of a typical large hump classification yard. The study of the proper width of driveways for team tracks and for freight houses is reported on, together with recommendations as to proper width for team driveways for various conditions. Under the heading of "Scales," the report makes recommendations as to the disposition of track scales which have been removed for various reasons.

Report of Committee on Economics of Railway Operation..Bulletin 302

J. M. Farrin, *Chairman*

The report contains the result of the study of the operating statistics and physical characteristics of a heavy traffic single-track road or section of road showing what traffic can be handled on a single-track railway. The problem of railway operation as affected by the introduction of motor trucks and bus lines, with particular reference to the effect upon branch or feeder lines, has been given further study and is reported on. Two interesting papers are included—one entitled "Rail car or motor coach—the economic field of each," and "The Baltimore and Ohio motor coach operation in New York."

Report of Committee on Economics of Railway Location..Bulletin 302

F. R. Layng, *Chairman*

A brief report of progress is made on the subject of the economics of grade revision as affected by the introduction of the electric locomotive. Progress is also reported on the relative merits of increasing tonnage by the reduction of ruling grades, or by the introduction of more powerful locomotives. A valuable contribution by a member of the Committee on "The Locomotive Booster" is included in the report.

Report of Committee on Economics of Railway Labor....Bulletin 302

A. N. Reece, *Chairman*

The extent to which it is practicable to stabilize employment in the Maintenance of Way Department is further reported on, and the conclusion is reached that the equalization of expenses permits work to be done at the most economical time, seasonal and traffic conditions considered; that it also prevents the distortion of operating ratios, while by its application more uniform forces may be employed in maintenance of way work, thereby tending towards stabilization of forces. The study of the determination of the extent to which maintenance of uniform forces is justified, leads to the conclusion that in consideration of the ultimate economy of building up a strong personnel of labor forces and the immediate economy of holding experienced men in maintenance of way service, as much work as is economically possible should be done in winter, thus stabilizing forces. The effect of stabilization of employment on uniform purchases of materials and on their costs is also reported on. Progress is reported on the subject of "Equating track values for labor distribution."

Report of Committee on Wooden Bridges and Trestles..Bulletin 302

W. E. Hawley, *Chairman*

The Committee is keeping in touch with the simplification of grading rules and classification of timber for railway uses, and points out that it is to the best interests of the railways to specify that all material be purchased under the new rules, as recommended last year. A revised specification for timber piles is submitted for approval. Study is being given the question of establishing supply yards for standard trestle timbers at various locations throughout the country. but no conclusions have as yet been arrived at.

Report of Committee on Rules and Organization.....Bulletin 302

W. C. Barrett, *Chairman*

For a number of years this Committee has been engaged in the preparation of a "Manual of Rules for the Guidance of Employees of the Maintenance of Way and Structures Department." The current report contains a revision of certain rules previously adopted; also, additional rules covering rules for the handling, framing and storing treated piling and timbers, and rules for the maintenance of other terminal structures, such as machine and other shop buildings, oil houses, coaling stations, ash pits, turntables, and track scales.

Report of Committee on Roadway.....Bulletin 303

C. W. Baldridge, *Chairman*

A mathematical theory of loads on culverts is presented; it covers what is available at the present time, and shows how it compares with the tests made under the auspices of the Committee at Farina, Ill. The Committee reports that roadbed deformations may, in general, be best eliminated by, first, preparing the roadbed to stand a reasonable load; second, applying such depth of ballast as would distribute the load applied that the pressure per square foot would not be greater than the capacity of the roadbed; and that in certain bad spots the use of concrete slabs might be a desirable remedy. Specifications for metal fence posts are presented, which in the judgment of the Committee will insure a post that will prove satisfactory, both as to strength and durability. The study of a permanent roadbed has been continued, and some interesting data is submitted. Proper methods for policing the right-of-way, with special reference to appearance and economy of maintenance, are discussed in an interesting manner, and various methods used on railways are cited.

Report of Committee on Rail.....Bulletin 303

EARL STIMSON, *Chairman*

The study of rail mill practice as affecting quality of steel rails has been continued, and an outline of the developments that have been made at various mills is given. Rail failure statistics for the year ending October 31, 1926, are reported, as in previous years. The construction of a transverse fissure detector device is one of the outstanding developments of the year. This device was developed under the auspices of the Rail Committee and financed by the American Railway Association. Cooperation with the Rail Manufacturers' Technical Committee has been established for the purpose of determining the original cause of transverse fissures in steel rails. The study of the cause and prevention of rail battering has been continued, in collaboration with the Track Committee, and progress is reported thereon.

Report of Committee on Track.....Bulletin 303

J. V. NEUBERT, *Chairman*

A number of changes in Track Plans heretofore approved are recommended. Plans for solid manganese crossings, movable point crossings, flanges or self-guarded frogs, and railbound manganese steel frogs are offered for approval. In connection with the study on track construction in paved streets, plans for iron-bound steel center frogs for 7-inch and 9-inch girder rails are submitted for approval. A plan for reinforced concrete and pile foundations under railway crossings is presented for approval, and three plans for tie layout for railroad crossings are submitted as information. All these plans have been prepared in conference with the Standardization Committee of the Manganese Track Society. Progress is reported on the study of methods of reducing rail wear on curves, particularly the oiling of the rail and wheel flanges. The cause and effect of brine drippings is reported on and the Committee recommends the study be continued and the scope broadened to include investigations of promising substitute refrigerants.

Report of Committee on Masonry.....Bulletin 303

C. P. RICHARDSON, *Chairman*

The study of specifications for reinforced concrete T-beams, columns and slabs has been continued, and a new specification for "Flexure of Reinforced Concrete T-beam" is submitted for approval. An interesting contribution on "Regulations for Flat Slabs" (Four-Way System), by M. Hirschthal, a member of the Committee, is presented. A report on the progress being made in methods of concrete manufacture is submitted, with particular reference to the inundation method of sand measuring. The specifications for foundations of a number of railways have been studied during the year; the Committee has selected certain abstracts that are typical of the open well dredging caisson, the pneumatic caisson, and the floating caisson founded on pile foundations, and these abstracts are made available as useful information. The results of a canvass made as to the general practices for waterproofing railway structures (bridges) is published as information.

Report of Special Committee on Stresses in Track.....Bulletin 304

ARTHUR N. TALBOT, *Chairman*

A report of progress is presented on the study made during the year on the rail joint, its function in the track, and the manner in which elements of the design of the joint affect its behavior in the track.

Report of Committee on Signals and Interlocking.....Bulletin 303

W. M. Post, *Chairman*

The present status of automatic train control is reported on, including a list of installations to date. Report is made as to highway crossing protection, including the code of colors and forms for traffic signals for highways and vehicles, recommended by the Sectional Committee for Code on Traffic Signals of the A. E. S. C. A synopsis of the principal current activities of the Signal Section, American Railway Association, supplemented with list and reference by number of adopted specifications, designs and principles of signaling practice, forms a valuable and useful addition to the report.

Report of Committee on Grade Crossings.....Bulletin 303

Hadley Baldwin, *Chairman*

A revised Highway Crossing Sign is submitted for approval. The methods of apportioning the cost of highway improvements adjacent to railway rights-of-way, with special reference to improvements in cities and towns, is discussed and the result of a questionnaire on the subject is given. The four types of crossing protection in use, as reported to the I. C. C., namely, gates, watchmen, signals and fixed signs, are discussed; plans for a flashlight or wigwag signal are offered for approval, and plans for advance warning sign and stop sign are also submitted for approval. The Committee submits the results of its study of the excessive number of highway grade crossings of railways, with methods of their removal. A comprehensive report on the laws and regulations affecting the apportionment of Federal aid, and the proper form and character of division of costs of separation of grades as between the railway, state, county, municipal or other corporation, is a valuable contribution.

Report of Committee on Wood Preservation.....Bulletin 304

F. C. Shepherd, *Chairman*

Definitions of terms used in "Wood Preservation" are submitted as information. Report is made on service test records for treated ties, including interesting statistics on cross-ties renewals. The result of recent inspections on the test pieces prepared by the Chemical Warfare Service, in connection with the Marine Piling Investigations, is given in detail. Report is made on the inspection of tests of creosote-petroleum treated ties on the Santa Fe; also on the inspection of zinc-petroleum and straight zinc chloride ties on the same railway. Progress is reported on the effect of preservative treatment with air-seasoned Douglas Fir.

Report of Committee on Records and Accounts.....Bulletin 304

J. H. Hande, *Chairman*

Report is made on the use of aerial surveys and results obtained therefrom, including a comprehensive bibliography. The Committee presents its conception of the assignment to collaborate with other committees in the preparation and design of forms pertinent to their work. The Committee submits an exhaustive report on the progress made in the revision of the Interstate Commerce Commission's accounting classifications; this study and report was made by Alfred Holmead, a member of the Committee. An interesting and valuable report is made on plans, methods and forms for gathering and recording data for keeping up to date the physical and valuation records of the property of railways; examples of the forms recommended are included, together with a list of units, prepared jointly by the Presidents' Conference Committee and the Bureau of Valuation, I. C. C., for reporting engineering work and costs.

Report of Committee on Buildings.....Bulletin 304

FRANK R. JUDD, *Chairman*

Artificial lighting for railway buildings is reported on, such as shops, offices and drafting rooms, passenger and freight stations, and coal chutes. Progress is reported on the subject of design and construction of water station buildings. A report is made on permissible grades for ramps in railway buildings. As a continuation of the general assignment "Specifications for Buildings for Railway Purposes," the Committee offers chapters on Concrete Pavements and Foundations; Creosoted Wood Block Pavements; Wood Block Floors; Asphalt Block Pavements, Asphalt Block Floors; Macadam Pavements, and Asphalt Macadam Pavements.

RELATIONS WITH OTHER ORGANIZATIONS

The co-operation of the Association has been invited in a number of directions by other organizations, including the following:

Committee on Automatic Train Control, American Railway Association

The members of the American Railway Engineering Association serving on this Committee are: W. P. Wiltsee, Chairman; A. W. Newton, Vice-Chairman; E. A. Hadley, E. B. Katte, H. E. Stevens, W. J. Eck, J. A. Peabody, T. S. Stevens.

Joint Committee on Drinking Water Supplies

This is also a committee of the American Railway Association, on which the following members represent the Engineering Division: Dr. S. C. Beach, Vice-Chairman; R. C. Bardwell, A. B. Pierce.

Joint Committee on Metric System of Weights and Measures

This joint committee was formed in 1927 by the American Railway Association to assist those in charge of railway interests in combating efforts made periodically to enact legislation having in view the compulsory introduction of the Metric System of Weights and Measures. W. D. Faucette has been designated as Chairman, assisted by John R. Leighty, W. P. Wiltsee and M. J. J. Harrison, as representing the engineering branch of railway service.

The Mississippi Flood of 1927

A special committee, composed of Chief Engineers of railroads operating in the area affected by the Mississippi Valley Flood of 1927, was appointed by President D. J. Brumley. The report of this special committee appears in Bulletin 297 for July, and a revision in Bulletin 303 for January, 1928.

Southern Appalachian Power Conference

The Sub-Committee on Water Power of the Electricity Committee was represented at this conference held at Chattanooga, Tenn., in October, 1927.

Advisory Committee on Tests of a Reinforced Concrete Bridge

J. B. Hunley, Engineer Bridges and Structures, Cleveland, Cincinnati, Chicago & St. Louis Railway, has been appointed to represent the Association on an advisory committee to arrange for a method and procedure for carrying on tests on a reinforced concrete bridge on the Yadkin River in North Carolina.

American Committee on Electrolysis

The Association is represented on the American Committee on Electrolysis by a Sub-Committee, consisting of Martin Schreiber, Chairman; W. M. Vandersluis, Vice-Chairman; E. B. Katte.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete

The American Railway Engineering Association is represented on this joint committee by T. L. D. Hadwen, F. E. Schall, C. C. Westfall, J. J. Yates.

Joint Committee on Concrete Culvert Pipe

A. F. Robinson and Job Tuthill represent the A.R.E.A. on this joint committee.

Marine Piling Investigations

Co-operation has been continued with the Chemical Warfare Service in the study of marine piling. The personnel of the American Railway Engineering Association representatives are Dr. Hermann von Schrenk, Chairman; Col. Wm. G. Atwood, C. S. Burt, G. F. Eberly, Andrew Gibson, W. H. Kirkbride.

American Engineering Standards Committee

W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad, is the representative of the Engineering Division on American Engineering Standards Committee. In the current report of the Committee on Standardization, Bulletin 300, October, 1927, pages 78-80, the projects in which members of the A.R.E.A. are serving on Sectional Committees are listed.

Joint Committee on Boiler Feed Water Studies

This committee is sponsored by the American Railway Engineering Association, the American Water Works Association, the National Electric Light Association, the American Society for Testing Materials, and the American Society of Mechanical Engineers. The object of the research work is to determine the fundamental principles underlying certain phenomena which take place in steam boilers. In Bulletin 298, August, 1927, a symposium of papers on various phases of these studies was published.

Specifications for Steel Highway Bridges

A conference committee composed of representatives of the American Railway Engineering Association and American Association of State Highway Officials has had under active study for the past several years the preparation of a specification for steel highway bridges. It is expected that the specifications will be presented to the members in the near future.

Rail Manufacturers' Technical Committee

The Committee on Rail is in close contact with the Technical Committee of Rail Manufacturers for the purpose of determining the primary causes of transverse fissures in steel rails, and if possible, to find a remedy.

Manganese Track Society

The Track Committee has collaborated for several years with the Standardization Committee of the Manganese Track Society in the preparation of trackwork plans for frogs, crossings and switches. Over one hundred plans have been prepared and have been approved by this Association.

Personnel of Committees by Railways—1927

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Contract Forms	Economics of Ry. Operation	Economics of Ry. Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Stresses in Track	Standardization	Clearances	TOTAL
Atlantic Coast Line											1	1							1	2				1			6
Akron, Canton & Youngstown											1																1
Ann Arbor			1						1																		2
Atchison, Topeka & Santa Fe	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1		1			1	1	21
Gulf, Colorado & Santa Fe																					1	1					2
Atlanta & West Point																					1						1
Baltimore & Ohio	1	1		2	1	2		1	4	1	1	2	1	1	1	1	1	1		2	3	1		2	2		32
B. & O. Chicago Terminal									1																		1
Bessemer & Lake Erie																1				2					1		4
Boston & Maine	1			1												1	1								1		5
Buffalo, Rochester & Pittsburgh																						1					1
Canadian National	1	1	1	1	2		1	1			1	1		1	2		1	1	1	3		1			1		21
Canadian Pacific	1	1		2	1	1		2	1			1		1	1	1	1			1	1	1	1		1	1	20
Central of Georgia		1	1			1	1						1						1								6
Central of New Jersey							1					1						1	1								4
Chesapeake & Ohio	1	1	2	1	1	1	1	1			1		3		1	3				2	2	2	1				24
Chicago & Eastern Illinois															1							1					2
Chicago & Northwestern	1	1							1	1		2	1		1			1	1			1					11
Chicago & Western Indiana		1			1						1	1		1								2			1	1	9
Chicago, Burlington & Quincy		1	2	1	2	1	1	1	1		1	1	1		1	1	1			1		1					18
Chicago Great Western												1															1
Chicago, Indianapolis & Louisville	1									1																	2
Chi. Mil. St. P. & Pac.			1	1			1	1			1		2	1			1	1		1		2					13
Chicago, Rock Island & Pacific		1	1	2	2	1		1	1	1	1	1	2	2	1		2			1	1	1	2	1	2	1	28
Chicago Rapid Transit										1																	1
Chicago, W. Pullman & Southern												1															1
Cleveland Union Terminals														1													1
Clinchfield																			1								1
Chicago, St. P., Minn. & Omaha																			1								1
Copper Range																1											1
Delaware, Lackawanna & Western	1	1		1	1		1	1						1				1					1	1			10
Delaware & Hudson														1						1							2
Duluth & Iron Range	1																					1					2
Duluth, Missabe & Northern							2																		1	1	4
Duluth, Winnipeg & Pacific																1											1
Elgin, Joliet & Eastern					1									1													2

Personnel of Committees by Railways—1927

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Contract Forms	Economics of Ry. Operation	Economics of Ry. Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Stresses in Track	Standardization	Clearances	TOTAL
Erie					1				1										1		1			1			5
Florida East Coast	1				1	1						1			1												5
Fort Worth & Denver City							1																				1
Grand Trunk Western								1											1		1	1					4
Great Northern			1					1					1				1										4
Gulf Coast Lines			1																								1
Hocking Valley							1																				1
Illinois Central			2	2	1	1	2	1	3	2	1	2	3	2		1	2	2	1	2	1		1		3	1	36
International Great Northern							1														1						2
Jacksonville Terminal														1													1
Johnstown & Stony Creek					1																						1
Kansas City Southern													1		1						1				1		4
Kansas City Terminal										1				1													2
Lake Superior & Ishpeming			1																								1
Lehigh Valley				1				1	1			1													1	1	6
Long Island																	2										2
Louisville & Nashville		1		1	1							1	1	1													6
Maine Central						1																					1
Minnesota International																						1					1
Missouri Pacific	1	1	1	1	1	1	3	1	1	2	2	1	2			2	1		1		1	1	1	2	1		28
Missouri-Kansas-Texas		1				1			1		2		2		1	1					1	1					11
Mobile & Ohio							1																				1
Montana, Wyoming & Southern															1												1
Nash., Chattanooga & St. Louis				1																	1						2
New York Central Lines				1													1	1				1					4
Boston & Albany																			1						1		2
Chicago Junction														1													1
Big Four		1	1				1		1		1				2						1	1			2	1	12
Indiana Harbor Belt		1							1																		2
Evansville, Ind. & Terre Haute																			1								1
Michigan Central					2		1		2	1								1			1						8
New York Central Railroad	1	2	2	1	2	2		1	3	2	1	2	1	1	3			2		2	2	1	1	1	3	3	39
Peoria & Eastern	1																			1							2
New York, Chicago & St. Louis					1		1								1				1								4
New York, New Haven & Hart.			1			2					1			1	1			2	1	2							11
Norfolk & Western	1			1					1					1	1			1				1					7

Personnel of Committees by Railways—1927

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Contract Forms	Economics of Ry. Operation	Economics of Ry. Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Stresses in Track	Standardization	Clearances	TOTAL
Norfolk Southern																			1								1
Northern Pacific			2	1		1	1	1	1				2	1		1	1			1	1						14
Pennsylvania	2		1	3	3		1	1	3	2		1	2	3	1	1	1	1		2			1	1	2	1	33
Peoria & Pekin Union		1																									1
Pere Marquette	1							1													1						3
Public Service of New Jersey																		1									1
Reading	1			1	1						1	1			1	1	1	1	1	1							11
Richmond, Fred. & Potomac		1												1													2
St. Louis-San Francisco	1						1		1				1								1		1				6
St. Louis Southwestern		1											1														2
Seaboard Air Line							1												1	1			1				4
Soo Line																	1										1
Southern	2	1			1			1		1			1		1				1								9
Southern Pacific	1	1	1	2	1		1		1	1			1			2	2					2					16
Temiskaming & Northern Ontario			1																								1
Term. R. R. Assn. of St. Louis					1							1					1										3
Texas & Pacific													1														1
Toronto Terminals														1											1		2
Union Pacific System				2					1	1	1		2		1												8
Oregon-Wash. R. R. & Nav. Co.																			1								1
Union Pacific Railroad																					1	1					2
United Railway Electric Co.			1																								1
Virginian																1											1
Wabash	1		1	1				1					1		1												6
Waterloo, Cedar Falls & Nor.									1																		1
Wheeling & Lake Erie		1																									1
Western Maryland														1													1
Western Pacific			1																								1
Non-Railroad Members	2	1	1		7	4	4	3	3	2	2	3	1	11	9	8	5	2	4	8	1	2	7	9			97
Totals	26	25	29	31	38	21	31	26	37	20	22	28	36	39	35	29	27	23	23	37	26	31	18	19	26	12	728

(II) PUBLICATIONS

The Bulletin

The Bulletin is the medium through which the Association disseminates the committee reports which are to be considered and acted on at the annual convention.

Through the effective co-operation of the various committee chairmen it has been made possible to issue the reports during the past year far enough in advance of the annual meeting to give ample time for their study and the preparation of discussion.

The Proceedings

The annual volume of the Proceedings is the permanent record of the Association's activities for the year. The volume contains the Constitution; a condensed summary of the Business Session; the committee reports in full, and the verbal and written discussions thereon; and, finally, the special articles contributed by members and others.

The Proceedings of the A.R.E.A. are properly conceded to be an encyclopedia of practical information of great value to the busy executive and to the railway officer in need of data on problems confronting him in his daily routine.

Volume 28, Proceedings for 1927, is a noteworthy contribution to the literature on the Science of Railway Engineering.

The Manual

The issuance of the revised Manual is under way and the new Manual will be published as soon as practicable after the annual convention. Approximately one-third of the material is in type, and satisfactory progress is being made on the remainder.

The "Manual of Recommended Practice" is the outstanding achievement of the Association. The volume represents the net results of its activities up to the present. The contents consist of Definitions; Specifications for Material and Workmanship; Plans and Designs, and Principles of Practice for railway construction, maintenance and operation.

The "Manual" has been and will continue to be an important factor in bringing about greater uniformity in practices and methods in railway engineering, and promote efficiency and economy in the operation of railroads.

In the promulgation of this comprehensive guide to good practice the American Railway Engineering Association has rendered a distinct service to the transportation industry.

The General Index

Progress is also being made in the compilation of the General Index. It is expected to publish this volume during the current year.

MONOGRAPHS

Eight unusually valuable contributions have been published in the respective Bulletins during the past year:

"The Mississippi Valley Flood—1927"

Bulletin 297 (July, 1927): Bulletin 303, Part 2 (January, 1928)

"Freight Train Curve-Resistance on a One-Degree and a Three-Degree Curve"

Bulletin 298 (August, 1927), by Edward C. Schmidt, Professor of Railway Engineering, University of Illinois.

"The Highway Grade Crossing Problem"

Bulletin 298 (August, 1927), by Robert H. Ford, Assistant Chief Engineer, Chicago, Rock Island and Pacific Railway

"Boiler Feed Water Studies"

Bulletin 298 (August, 1927), Symposium of Papers Presented to American Society of Mechanical Engineers and American Water Works Association

"Sink-Head Ingots"

Bulletin 299 (September, 1927), by R. S. Harden, Office Engineer, The Pennsylvania Railroad

"Traffic Capacity of a Railway"

Bulletin 299 (September, 1927), by H. Parodi, Consulting Engineer, Paris - Orleans Railway (France); Comments by Committee on Economics of Railway Operation

"A Simplified Column Formula of the Secant Type"

Bulletin 300 (October, 1927), by J. B. Hunley, Engineer Bridges and Structures, Cleveland, Cincinnati, Chicago and St. Louis Railway

"The Purchase of Materials, Tools, Appliances and Supplies"

Bulletin 303 (January, 1928), by W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad

Special articles on subjects pertaining to the field of railway engineering are desired and welcomed, and members are urged to present to the Association the results of any special studies or investigations for publication in the Bulletins.

(III) MEMBERSHIP

The additions, changes and losses in the membership rolls during the year are indicated in the following table.

Membership as of March 1, 1927			2,511
Additions during the year		173	
Losses by death	29		
Resignations	30		
Dropped from rolls	18	77	
Net gain		96	
Total membership as of March 1, 1928			2,607

Increase in Membership

The Membership Committee has continued its effective work of the past, augmented by hearty response from the Standing Committees and from individual members. The results of these combined efforts are evident in the number of applications received during the past two months.

A considerable number of railway officials and others have not as yet affiliated with the Association, who would be desirable members. The affiliation of such men would be mutually advantageous—they would be helpful to the Association and extend its usefulness, and in turn it would aid them to keep posted on developments in railway engineering.

The following is quoted from an appeal addressed to the membership by President Brumley in Bulletin 302 for December, 1927: "The field from which to draw on for desirable members covers the Operating, Engineering, Mechanical, Electrical and Purchasing Departments of railways; also, Civil and Consulting Engineers, Government officials whose duties relate to Transportation, and members of college faculties. An invitation from a personal friend extended to an eligible prospect to affiliate with the Association is frequently sufficient to secure a most desirable addition to the membership rolls."

Benefits of Membership

Among the benefits of membership in the American Railway Engineering Association might be emphasized: (1) Contact with high-class, able men from all sections of the American continent, all interested in the same problems; the forming of new and valuable friendships; the comparison of views and exchange of experiences on matters of mutual concern at the annual meetings; (2) The opportunities committee-work affords for the enrichment of personal qualification and attainment; (3) Access to the publications of the Association, with their wealth of practical and useful information; (4) The personal satisfaction that comes from active participation in worth-while work and rendering a service for the common good.

CLASSIFICATION OF MEMBERSHIP

The following table is a departmental classification of the membership:

General Officers	165
Includes Chairmen of Boards, Presidents, Directors, Vice-Presidents, Assistants to Presidents, General Managers, Assistant General Managers	
Conducting Transportation	103
Includes General and Assistant General Superintendents, Division Superintendents, Trainmasters	
Maintenance of Way and Structures	1785
Includes Chief Engineers, Chief Engineers of Maintenance of Way, Engineers Maintenance of Way, Bridge Engineers, Division Engineers, Signal Engineers, Assistant Engineers, etc.	
Maintenance of Equipment	22
Includes General Superintendents of Motive Power, and other Mechanical Department Officers	
Traffic Officers	5
Accounting Officers	11
Purchasing and Stores Department	3
Professors in Colleges	63
Miscellaneous	450
Includes Consulting and Civil Engineers, Engineers of Industrial Corporations, Government and Municipal Engineers, etc.	
Total	2607

The inference to be drawn from these figures is that railway officers connected with departments other than Engineering consider it advantageous to be identified with this progressive organization.

It is highly gratifying to record the fact that the Presidents of forty-seven of the larger railway systems in the United States and Canada are enrolled as members of the A.R.E.A. The following table is a list of these roads.

Akron, Canton & Youngstown
Atchison, Topeka & Santa Fe
Atlanta, Birmingham & Atlantic
Augusta & Summerville
Canadian National
Canadian Pacific
Central of Georgia
Central of New Jersey
Chesapeake & Ohio
Chicago, Burlington & Quincy
Chicago Great Western
Chicago, Rock Island & Pacific
Chicago & Eastern Illinois
Colorado & Wyoming
Denver & Rio Grande Western
Delaware, Lackawanna & Western
Duluth, Missabe & Northern
Elgin, Joliet & Eastern
Eureka & Nevada
Great Northern
Huntingdon & Broad Top Mountain
Illinois Central
Jacksonville Terminal
Kansas City Southern
Lehigh Valley
Louisville & Nashville
Missouri Pacific
Montana, Wyoming & Southern
New York Central Lines
New York, New Haven & Hartford
Northern Pacific
Norfolk & Western
Pennsylvania
Peoria & Pekin Union
Pere Marquette
Reading
Richmond, Fredericksburg & Potomac
St. Louis-San Francisco
Seaboard Air Line
Southern Pacific
Tennessee Central
Terminal Railroad Ass'n-St. Louis
Toledo Terminal
Union Pacific System
Wabash
Western Maryland
Western Pacific

Representing 189,570 miles of railroad.

Deceased Members

We express our sorrow and regret at the passing away of thirty valued members during the year.

The list of deceased members contains the names of four Charter Members; a Past-President, and two Treasurers of the Association.

C. I. Anderson,
Assistant Engineer of Buildings, Illinois Central Railroad

Willard Beahan,
First Assistant Engineer (retired), New York Central Railroad, West of Buffalo

W. P. Bruce,
Vice-President and General Manager, Nashville, Chattanooga & St. Louis Railway

George H. Bremner,
Formerly District Engineer, Chicago, Burlington & Quincy Railroad; District Engineer, Bureau of Valuation Interstate Commerce Commission; Treasurer of the Association from 1911 to 1927.

William H. Burrage,
Division Engineer, New York, Chicago & St. Louis Railroad

William S. Dawley,
Charter Member, First Treasurer; Formerly Chief Engineer, Chicago & Eastern Illinois; also Chief Engineer, Yunnan-Szechuan-Tengyueh Railway of China; Consulting Engineer.

George Eisenhauer,
Electrical Engineer, Erie Railroad

William L. Ekin,
Chief Engineer Maintenance of Way, Western Region, The Pennsylvania Railroad

Edwin O. Faulkner,
Manager Tie and Timber Department, Atchison, Topeka & Santa Fe Railway System

Charles F. W. Felt,
Charter Member; President, 1926; Past-President, 1927; Chief Engineer, Atchison, Topeka & Santa Fe Railway System

A. S. Going,
Terminal Engineer, Canadian National Railways

Charles B. Hoyt,
Charter Member; Retired Superintendent of Track, New York, Chicago & St. Louis Railroad

DECEASED MEMBERS—Continued

WILLIAM H. HOYT,
Chief Engineer, Duluth, Missabe & Northern Railway

C. W. HUNTINGTON,
Formerly President, Virginian Railway

T. J. IRVING,
Division Engineer, Chicago & Northwestern Railway

JOHN D. KEILEY,
Division Engineer, Chesapeake & Ohio Railway

W. P. KIMBLE,
Assistant Engineer, Erie Railroad

PAUL KIRCHER,
Vice-President, Canada Concrete Products Company

GEORGE A. MOUNTAIN,
Charter Member; Formerly Chief Engineer, Dominion Atlantic Railroad of Canada; Chief Engineer, Canadian Railway Commission

F. P. PATENALL,
Signal Engineer, Baltimore and Ohio Railroad

F. P. PELTER,
General Manager, Norfolk Southern Railway

KENNETH G. POLYBLANK,
Assistant Chief Engineer, Rouyn Mines Railway Company, a Subsidiary of the Canadian National Railways

A. C. PRIME,
Consulting Engineer, Philadelphia, Pa.

C. J. SCRIBNER,
Engineer of Scales, Chicago, Burlington & Quincy Railroad

H. T. SPENGLER,
Professor of Railway Engineering, Lafayette College

ARTHUR C. SMITH,
Vice-President, Morden Frog and Crossing Works

GEORGE W. SNYDER, II,
Assistant Chief Engineer, The Pennsylvania Railroad

CHARLES YODER,
Engineer Maintenance of Way, New York Central Railroad, Lines West of Buffalo

S. DAVIES WARFIELD,
President, Seaboard Air Line Railway

H. K. WICKSTEED,
Locating Engineer, Canadian National Railways

GEOGRAPHICAL DISTRIBUTION OF MEMBERSHIP

United States and Possessions

Alabama	7	Nebraska	28
Alaska	1	New Jersey	45
Arizona	5	New Hampshire	6
Arkansas	37	New Mexico	3
California	75	New York	240
Colorado	15	North Carolina	22
Connecticut	31	North Dakota	4
District of Columbia	32	Ohio	140
Florida	26	Oklahoma	20
Georgia	52	Oregon	9
Hawaii	1	Pennsylvania	185
Idaho	8	Philippine Islands	2
Illinois	354	Porto Rico	1
Indiana	48	Rhode Island	6
Iowa	26	South Carolina	3
Kansas	63	South Dakota	1
Kentucky	37	Texas	109
Louisiana	25	Tennessee	24
Maine	11	Utah	6
Massachusetts	54	Vermont	8
Missouri	209	Virginia	79
Maryland	65	Washington	25
Michigan	63	West Virginia	26
Mississippi	16	Wisconsin	15
Minnesota	64	Wyoming	3
Montana	12		
			2347

Other Countries

Canada	139	Manchuria	2
Japan	32	Siam	2
South America	14	Persia	2
China	12	Czecho-Slovakia	1
India	7	Ireland	1
Mexico	7	Scotland	1
Cuba	7	France	1
Australia	5	New Zealand	1
Africa	5	Poland	1
England	4	Spanish Honduras	1
Costa Rica	2	Sudan	1
Korea	2	Sweden	1
Egypt	2	Turkey	1
Union Socialistic Soviet Republic	2	Jamaica	1
Central America	2	Malay States	1
			260

(IV) FINANCES

Financial Statement

Exhibit A is a record in detail of the receipts and expenditures during 1927. The statement shows a slight excess of receipts over disbursements.

It may not be out of place to point out that although the cost of printing and other items required in the conduct of the Association have very materially increased in the past ten years, the Association has not increased the dues of the members.

Included in the Financial Statement is the status of the Stresses in Track Fund. This fund was contributed by commercial companies to aid in the study of stresses in the track. In recent years the American Railway Association has annually made substantial financial contributions to this important investigation.

(V) MISCELLANEOUS

Changes in the Board of Direction

The death of George H. Bremner on April 2, 1927, caused a vacancy in the office of Treasurer.

F. J. Stimson, Assistant Chief Engineer Maintenance, The Pennsylvania Railroad, was appointed to fill the vacancy.

J. de N. Macomb resigned as Director on account of leaving railway service.

W. J. Backes, Chief Engineer, Boston & Maine Railroad, was appointed a Director for the unexpired term of Mr. Macomb.

Frank Lee also resigned as Director on account of transfer of headquarters to the Pacific Coast.

J. E. Armstrong, Assistant Engineer, Canadian Pacific Railway, was appointed a Director for the unexpired term of Mr. Lee.

Past-President C. F. W. Felt passed away on February 4, 1928.

Transverse Fissure Detector Car

The device developed under the auspices of the Committee on Rail in 1927, designed to detect the type of rail failure known as a "transverse fissure," is nearing completion, and a trial test is to be made in the near future. The construction of this car has been financed by the American Railway Association. The apparatus is described in the report of the Committee on Rail, page 971, Volume 28, of the Proceedings for 1927.

In a supplemental report to be issued prior to the annual meeting, the Rail Committee will give more detailed information of this device.

Use Made of A.R.E.A. "Recommended Practice"

In the report of the Special Committee on Standardization, reference is made to the result of an inquiry among members of that Committee as to the use made by railways with which the respective members are connected, of the "recommended practice" of the Association. This partial survey indicates that the recommended practice of the Association is receiving constantly wider application and use by railway companies.

Historical Note

The preliminary meeting at which the Association was launched on its successful career was held at the Iroquois Hotel, in Buffalo, New York, on March 30, 1899. At that meeting the Constitution was presented and adopted, and the first officers elected and installed.

The accompanying illustration shows the location of the Iroquois Hotel in the shopping district of Buffalo. The building is now used for office purposes. It is reproduced as a matter of historical interest.

We are indebted for the view of this old landmark—the birthplace of the A.R.E.A.—to Mr. Franklin E. Abbott, Civil Engineer, of Buffalo, a veteran member of the Association.

Token of Appreciation

The Mississippi Valley Flood of 1927 afforded ample scope for the display of those characteristics for which railway men are noted—loyalty and devotion to duty; courage; endurance; resourcefulness—all summed up in the word "Service."

Although the railways in the flooded area suffered enormous losses, their first concern was the relief of the stricken people.

The Board of Direction has therefore deemed it fitting and proper to take cognizance of the outstanding services rendered by railway men in this emergency, and has caused an engrossed Certificate of Appreciation, of which the illustration below is a reduced reproduction, to be awarded to the following railway officers:

American Railway Engineering Association

AMERICAN RAILWAY ENGINEERING ASSOCIATION

In Appreciation of distinguished and meritorious services rendered in rescue and relief work during the Mississippi Valley Flood of 1927, this token of appreciation is awarded to

William Smith

on behalf of the American Railway Engineering Association.

E. H. Fritch, Secretary

President

Chicago, Rock Island & Pacific Railway

F. T. Beckett
J. G. Bloom
A. C. Bradley
Robert H. Ford
L. C. Fritch
F. P. Funda
J. A. Giles
J. R. Hayes
W. E. Heimerdinger
L. J. F. Hughes
H. T. Livingston
J. A. McDougal
F. Nugent
L. L. Parks
C. A. Richards
I. L. Simmons

Illinois Central System

Wm. Atwill
M. M. Backus
S. C. Beach
A. F. Blaess
L. H. Bond
C. M. Chumley
A. E. Clift
F. J. Coates
E. L. Crugar
T. P. Crymes, Jr.
L. A. Downs
J. L. Downs
B. C. Ellis
W. R. Gillam
J. P. Hanley
C. J. Harrington
S. C. Jump
J. W. Kern, Jr.
C. R. Knowles
C. H. Markham
J. K. Melton
M. B. Morgan
G. M. O'Rourke
G. E. Patterson
T. M. Pittman, Jr.
H. J. Rhodes
J. E. Rogan
J. C. Stamm
C. I. Van Arsdalen
J. F. Walker
F. G. Walter, Jr.
C. C. Westfall

Louisiana & Arkansas Railway

C. G. Lunday
E. F. Salisbury

Louisiana Railway & Navigation Company of Texas

W. C. Borchert
C. R. Mee
Paul Sipple

Missouri-Kansas-Texas Lines

Frank Ringer

Missouri Pacific Lines

L. W. Baldwin
J. S. Bassett
F. E. Bates
C. E. Bishop
A. F. Bradford
W. E. Brooks
H. M. Bryant
V. B. Buckley
R. G. Bush
A. S. Butterworth
John Cannon
R. H. Carpenter
C. P. Cathers, Jr.
A. B. Chaney
C. E. Cherry
C. R. Chevalier
R. N. Clarke
L. L. Coffey
C. F. Cole, Jr.
C. M. Cowsert
L. Craine
A. F. Crowder
J. M. Crutsinger
W. A. Davidson
A. F. Dorley
E. M. Durham, Jr.
E. B. Fithian
E. L. Freeland
P. M. Gault
J. M. Giles
W. H. Giles
A. A. Gloeckner
J. H. Greason
J. E. Grund
E. A. Hadley
D. S. Hair
V. C. Halpin
E. Haner
J. G. Harrell
R. P. Hart
E. P. Hawkins
W. P. Hayes
O. G. Heimbuecher
L. A. Henry
C. A. Hewes
W. H. Hobbs
J. M. Hopton
C. R. Hornecker
H. A. Israel
C. J. Jaeschke
J. W. James
F. A. Jones
A. E. Kasch
W. A. Kennon
R. P. King
C. S. Kirkpatrick
H. D. Knecht
J. A. Lahmer
L. L. Lowe
W. R. Luhn

Missouri Pacific Lines—Continued

J. H. McFadden
J. W. Marshall
L. C. Marshall
A. D. May
J. F. Mayne
A. A. Miller
Harry Miller
A. P. Morrison
W. F. Murray
J. R. Nagel
P. J. Jeff
W. M. Neptune
H. M. Noel
J. Novak, Jr.
G. W. Payne
J. A. Reed, Jr.
W. R. Rhodes
H. H. Richardson
H. R. Safford
C. S. Sample
A. P. Schmitt
J. H. Sheiber
F. S. Schwinn
J. Sicht
P. T. Simons
G. S. Smith
R. M. Smith
H. Stringfellow
Earl Sullivan
R. G. Sutton
W. C. Swartout
T. L. Thibeau
D. F. Tracy
J. W. Treadwell
O. R. Unger
W. H. Vance
P. P. Wagner
D. C. Wamsley
R. E. Warden
L. S. Werthmuller
G. R. Westcott
H. H. White
R. C. White
E. J. Wildermuth
S. L. Wonson
L. D. Woods
F. R. Woolford

St. Louis-San Francisco Railway

J. H. Brooking
H. B. Barry
J. E. Hutchison
F. G. Jonah
J. M. Kurn
G. W. Koontz

St. Louis Southwestern Railway

F. W. Green
W. S. Hanley
W. G. Hazlewood
J. F. McCurdy
W. E. McGraw
W. V. Parker
H. W. VanHovenberg

Cleveland, Cincinnati, Chicago & St. Louis Railway

Hadley Baldwin
C. F. Hinchman
W. C. Kegler
R. B. Stokley

Missouri & North Arkansas Railway

H. J. Armstrong

Mobile & Ohio Railroad

H. Austill
J. V. Johnston
B. A. Wood

Southern Pacific Company

H. M. Lull
F. C. Watkins
R. F. Wills
L. H. Cecil
R. M. Glover
P. B. Torian
H. H. Ueckert
Thos. Scott
Louis Church
A. B. Ashmore
E. J. Legendre
Chas. Black
J. D. Kelly
August Wehner
P. L. Green
Geo. O. Broussard
F. B. Lafleur

Texas & Pacific Railway

J. A. Somerville
J. F. Mitchell
R. H. Gaines
A. J. Chester
R. L. Holmes
R. J. Gammie

Exhibit A

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1927

Balance on hand January 1, 1927		$53,743.20
RECEIPTS		
Membership Account		
Entrance Fees	$ 1,850.00	
Dues	24,799.79	
Binding Proceedings and Manual	1,802.95	
Badges	16.00	
Sales of Publications		
Proceedings	2,779.90	
Bulletins	1,678.01	
Manual	494.50	
Specifications	826.76	
Leaflets	219.00	
Track Plans	409.75	
Advertising		
Publications	2,975.20	
Interest Account		
Investments	2,217.50	
Bank Balance	152.81	
Annual Meeting		
Sale of Dinner Tickets	4,980.00	
Miscellaneous	52.83	
American Railway Association		
Rail Investigations	8,408.51	
Total	$53,663.51	
DISBURSEMENTS		
Salaries	$ 9,769.92	
Proceedings	5,903.82	
Bulletins	14,346.55	
Track Plans	120.00	
Stationery and Printing	2,879.38	
Rents, Light, etc	845.00	
Supplies	502.28	
Expressage	711.34	
Postage	1,034.41	
Exchange	95.44	
Committee Expenses	170.30	
Officers' Expenses	116.40	
Annual Meeting	6,791.24	
Refund Dues, etc	21.00	
Audit	155.00	
Miscellaneous	706.62	
American Railway Assn.—Rail Investigations	9,232.56	
Total	$53,401.26	
Excess of Receipts over Disbursements		$ 262.25
Balance on hand December 31, 1927		$54,005.45
Consisting of:		
Bonds at Cost	$43,285.89	
Cash in S. T. & S. Bank	10,694.56	
Petty Cash Fund	25.00	
	$54,005.45	

STRESSES IN TRACK FUND

Balance on hand January 1, 1927	$ 1,913.40
Received from Interest during 1927	54.34
Total	$ 1,967.74
Paid out on audited vouchers during 1927	62.87
Balance on hand December 31, 1927	$ 1,904.87

Respectfully submitted,

BOARD OF DIRECTION.

REPORT OF THE TREASURER

Balance on hand January 1, 1927		$53,743.20
Receipts during 1927	$53,663.51	
Paid out on audited vouchers	53,401.26	
Excess of Receipts over Disbursements		262.25
Balance on hand December 31, 1927		$54,005.45
Consisting of:		
Bonds at Cost	$43,285.89	
Cash in S. T. & S. Bank	10,694.56	
Petty Cash Fund	25.00	
	$54,005.45	

STRESSES IN TRACK FUND

Balance on hand January 1, 1927	$ 1,913.40
Received from Interest during 1927	54.34
Total	$ 1,967.74
Paid out on audited vouchers during 1927	62.87
Balance of fund on hand December 31, 1927	$ 1,904.87

The Securities listed above are in a safety deposit box of the National Bank of the Republic, Chicago, Illinois.

Respectfully submitted,

F. J. STIMSON,

Treasurer.

I have made an audit of the accounts of the American Railway Engineering Association for the year ending December 31, 1927, and find them to be in accordance with the foregoing financial statements.

CHARLES CAMPBELL,

Auditor.

GENERAL BALANCE SHEET

December 31, 1927

Assets	1927	1926
Due from Members	$ 3,773.78	$ 3,578.45
Due from Sale of Publications	1,233.96	479.65
Due from Advertising	3,275.00	3,357.50
Due from A.R.A.—Rail Investigations	1,487.25	670.45
Furniture and Fixtures	997.40	997.40
Gold Badges	45.00	55.00
Publications on hand (Estimated)	6,000.00	6,000.00
Manual	500.00	900.00
General Index	3,269.89	3,269.89
Extensometers	500.00	500.00
Investments (Cost)	43,285.89	45,785.89
Interest on Investments (Accrued)	288.19	301.47
Cash in Standard Trust & Savings Bank	10,694.56	7,932.31
Petty Cash Fund	25.00	25.00
Total	$75,375.92	$73,853.01
Liabilities		
Members' Dues paid in advance	$ 7,573.00	$ 7,487.43
Impact Test Fund on Electrified Railways	285.46	285.46
Advertising paid in advance		20.00
Due for printing Bulletins		1,385.85
Surplus	67,517.46	64,674.27
Total	$75,375.92	$73,853.01

The President:—You have heard the reports of the Secretary and Treasurer. What is your pleasure?

Mr. V. T. Boughton (Engineering News Record):—I move the reports be accepted as read.

(The motion was seconded, put to a vote and carried.)

The President:—If you will refer to page 18 of the Secretary's report, you will see a list of deceased members. This list is as follows:

C. I. Anderson
Willard Behan
W. P. Bruce
George H. Bremner
William H. Burrage
William S. Dawley
George Eisenhauer
William L. Ekin
Edwin O. Faulkner
Charles F. W. Felt
A. S. Going
Charles B. Hoyt
William H. Hoyt
C. W. Huntington
T. J. Irving
John D. Keiley
W. P. Kimble
Paul Kircher
George A. Mountain
F. P. Patenall
F. P. Pelter
Kenneth G. Polyblank
A. C. Prime
C. J. Scribner
H. T. Spengler
Arthur C. Smith
George W. Snyder, II
Charles Yoder
S. Davies Warfield
H. K. Wicksteed

These men have faithfully assisted you in the work of your Association, and I should like to ask you to join me for one minute and stand in silence in their honor.

(The audience stood in silent tribute to the deceased members.)

The President:—The privileges of the floor are extended to visiting railway officials not members of the Association, and to professors of colleges, and they are invited to take part in the discussion of subjects in which they may be interested.

The Secretary will read two letters, one from a Past-President and now the ranking Past-President of the Association, and the other from the President of the American Railway Association.

Secretary E. H. Fritch then read the two letters, as follows:

"My Dear Mr. Brumley:

"Your letter of the 18th reached my home the same day that I returned from the hospital where I had been flat on my back for three months. I am still a wheel-chair semi-invalid but the doctors say I will be all right in the not distant future.

"For this reason I cannot attend the dinner on March 5th. It was good of you to write me as you did and my loyalty to the American Railway Engineering Association is so great that being present would have been a very great pleasure.

"The growth of the Association and the good work that it has always done fulfill the expectations and anticipations that we felt were in store for it when I had the honor of being its President.

"With best wishes for yourself and for the Association always,

"Sincerely but regretfully yours,

"George W. Kittredge."

"My Dear Mr. Brumley:

"I have been looking forward for the past two weeks to being able to accept your very kind invitation and to be with you at Chicago at the meeting of the American Railway Engineering Association and of Division IV of the American Railway Association. However, I find at the last moment that matters requiring my personal attention at Washington are going to prevent my being with you.

"Your Association has my congratulations on the thorough manner in which their work is being done and I can testify as to its value as fulfilling its part in the program of efficiency and economy permeating all departments of the transportation machine.

"You always do have a most successful and enthusiastic meeting, and I know that you will at this time. Please be assured, for yourself and your successors, that if there is any way in which the officers of the Association and myself can be helpful to you in any of the work you are undertaking, all you have to do is to let us know.

"With kind personal regards, I am

"Yours very truly,

"R. H. Aishton, *President.*"

The President:—The National Railway Appliance Association has collected and has set up for you a very interesting exhibit at the Coliseum. That exhibit is open during today, tomorrow and Thursday. At any time you find you can leave the convention hall without sacrificing your interest in the Association, or the interest of the Association itself, you might consider taking a look at the exhibit. I understand the exhibit is open evenings; this may give some of you who are busy at the three-day sessions an opportunity of seeing it.

The next order of business is consideration of reports of standing committees.

You will observe by the program that the Committee on Standardization is now scheduled to make its report. Will the members of that Committee please come forward?

In the absence of the Chairman, the report will be presented by Mr. C. R. Knowles.

(For Report, see pp. 65-90.)

The President:—The next Committee to report is Committee XX—Uniform General Contract Forms. The report will be presented by the Chairman, Mr. J. C. Irwin.

(For Report, see pp. 91-121.)

The President:—The Committee on Water Service will please come to the platform. The report will be presented by Mr. C. R. Knowles, Chairman.

(For Report, see pp. 123-196.)

AFTERNOON SESSION

(First Vice-President Louis Yager in the Chair.)

Vice-President Yager:—The first order of business on the program is the report of the Tie Committee. In the absence of the Chairman and the Vice-Chairman, the report will be presented by Mr. R. S. Belcher.

(For Report, see pp. 197-254.)

Vice-President Yager:—The next report is that of the Committee on Ballast. The report will be presented to you by the Chairman, Mr. Paul Hamilton.

(For Report, see pp. 355-363.)

Vice-President Yager:—The next Committee is that on Iron and Steel Structures.

The report of the Committee on Iron and Steel Structures will be presented by Mr. B. R. Leffler, Chairman.

(For Report, see pp. 365-374.)

Vice-President Yager:—The Chair will appoint the following members as Tellers to canvass the votes cast for officers for the ensuing year:

G. M. Strachan, *Chairman,* Atchison, Topeka & Santa Fe;
H. E. Silcox, Chesapeake & Ohio;
F. J. Bishop, Toledo Terminal;
W. C. Swartout, Missouri Pacific;
C. M. Bardwell, Missouri-Kansas-Texas;
S. M. Sherman, Illinois Central;
M. P. Black, Illinois Central;
E. F. Kleeberg, Illinois Central;
C. C. Haire, Illinois Central;
V. I. Smart, Canadian National;
M. M. Backus, Illinois Central.

The Secretary will turn over the ballots to the Tellers, who will canvass the votes and be prepared to make a report at the close of the session Wednesday afternoon.

The Secretary received this morning a letter from Mr. J. B. Hunley, Engineer of Bridges and Structures of the Big Four, who is also a member of this Committee, giving some interesting information in connection with tests which were made on the Swift Island Bridge off the Yadkin River in North Carolina. This will be communicated to you in the next Bulletin that is published so it will be a part of the report of this Committee.

(President D. J. Brumley in the Chair.)

The President:—The Committee on Wooden Bridges and Trestles will come to the platform. Mr. W. E. Hawley, the Chairman, will present the report.

(For Report, see pp. 503-511.)

The President:—The Committee on Shops and Locomotive Terminals will please come to the platform. The report will be presented by Mr. F. E. Morrow, Chairman.

(For Report, see pp. 375-395.)

The President:—The report of the Committee on Rules and Organization will be presented by Mr. W. C. Barrett, Chairman.

(For Report, see pp. 513-524.)

WEDNESDAY, MARCH 7, 1928

MORNING SESSION

The President:—The first report this morning is that of the Committee on Electricity. Following the custom established a year ago, the meeting will resolve itself into the annual session of the Electrical Section. Mr. Sidney Withington, Vice-Chairman of the Electrical Section, will preside.

The members of the Electrical Section will please come to the platform. Mr. Withington, Vice-Chairman of the Electrical Section, will conduct the meeting and receive the report of the Electricity Committee.

(For Report, see pp. 255-353.)

The President:—I believe it would be proper at this moment for the American Railway Engineering Association to accept the report of the Committee on Electricity which has just been presented in the annual report of the Electrical Section. The Chair will entertain a motion to that effect.

(A motion was regularly made, seconded, and carried, that the report of the Committee on Electricity be accepted.)

The President:—The next report is that of the Committee on Signals and Interlocking. I will ask Mr. C. H. Tillett to preside while the Committee is making its report.

(For Report, see pp. 641-674.)

The President:—The report of the Committee on Yards and Terminals will be presented by Mr. J. E. Armstrong, Chairman.

(For Report, see pp. 397-438.)

The President:—The Committee on Economics of Railway Operation will please come to the platform. Mr. J. M. Farrin will present the report.

(For Report, see pp. 439-474.)

AFTERNOON SESSION

The President:—The next subject for presentation is the report of the Committee on Economics of Railway Location. Mr. F. R. Layng, the Chairman, will present the report.

(For Report, see pp. 475-489.)

(Past-President J. L. Campbell in the Chair.)

Past-President Campbell:—The report of the Committee on Economics of Railway Labor will be presented by the Chairman, Mr. A. N. Reece.

(For Report, see pp. 491-501.)

Past-President Campbell:—The report of the Track Committee will be presented by Mr. J. V. Neubert, Chairman.

(For Report, see pp. 593-604.)

(President D. J. Brumley in the Chair.)

The President:—Before we adjourn I would like to have the Secretary announce the result of the election of officers.

Secretary E. H. Fritch:—The report of the Tellers is as follows:

REPORT OF THE TELLERS

To the American Railway Engineering Association:

We, the Committee of Tellers, report the following as the result of the count of ballots:

For President:	*Votes*
W. D. Faucette	1,252
J. B. Cox	1
F. E. Morrow	1
For Vice-President:	
G. D. Brooke	1,252
For Treasurer:	
F. J. Stimson	1,253
For Secretary:	
E. H. Fritch	1,254
For Directors (three to be elected):	
A. N. Talbot	652
Hadley Baldwin	638
F. E. Morrow	500
C. W. Baldridge	489
C. C. Cook	429
C. R. Harding	417
John V. Hanna	326
H. M. Stout	193
J. A. Peabody	162
For Members of Nominating Committee (five to be elected):	
T. T. Irving	834
F. W. Green	690
Maro Johnson	653
W. A. Clark	628
R. C. Bardwell	623
H. L. Ripley	606
C. M. McVay	605
J. B. Jenkins	564
B. H. Mann	543
J. C. Irwin	401
W. R. Bennett	1
G. J. Ray	1
F. R. Judd	1
C. P. Richardson	1
C. R. Knowles	1
Lem Adams	1

(Signed) COMMITTEE ON TELLERS,
GEORGE M. STRACHAN, *Chairman.*

The President:—There is just one other matter I wish to call to your attention. The membership of this Association is made up of Chief Executive Officers of railways, Operating Officers, Chief Engineers and subordinate Engineers. The membership now exceeds 2600. Among the 2600, we have a member, Miss Olive Wetzel Dennis, Engineer of Service of the Baltimore & Ohio Railroad Company. I would like Miss Dennis to please arise in her place, so you may know her as a member of the Association. (Applause.)

Miss Olive W. Dennis (Baltimore & Ohio):—Mr. President and Fellow-Members of the A.R.E.A.: That very gracious introduction seems to

demand some sort of acknowledgment, although I claim no credit as a public speaker. They say that public speaking is the art of taking two minutes' worth of ideas and diluting them with an hour's worth of vocabulary. When you have no ideas your vocabulary does not help you.

There is one thing I should like to say to you. There is sort of a widespread and popular impression that engineering is strictly a masculine profession, and that Engineers always have resented, and always would resent, any feminine encroachment upon their domain. I must say that that idea is all wrong, as far as my own experience is concerned, judging first by my experience as a student in the College of Engineering at Cornell; from my association with the engineering officers of the Baltimore & Ohio Railroad; from the reception of my application for membership in your Association, and the treatment I have received since I have attended my first convention as a member.

Here I am, a member of just one year's standing, with no point of distinction except the one of sex, and I have been singled out for a personal introduction. (Applause.)

THURSDAY, MARCH 8, 1928

MORNING SESSION

The President:—The report of the Committee on Rail will be presented by Mr. Earl Stimson, Chairman.

(For Report, see pp. 557-592.)

(Past-President Edwin F. Wendt in the Chair.)

Past-President Wendt:—The report of the Committee on Roadway will be submitted by the Chairman, Mr. C. W. Baldridge.

(For Report, see pp. 525-555.)

(President D. J. Brumley in the Chair.)

The President:—The report of the Masonry Committee will be presented by Mr. C. P. Richardson, Chairman.

(For Report, see pp. 605-640.)

The President:—Mr. G. D. Brooke, our newest Vice-President, will hear the report of the Committee as Presiding Officer. (Applause.)

(Vice-President G. D. Brooke in the Chair.)

Vice-President Brooke:—Mr. Hadley Baldwin, Chairman of the Committee, will present the report, which is found on page 675 of Bulletin 303.

(For Report, see pp. 675-706.)

AFTERNOON SESSION

The President:—Will the Special Committee on Stresses in Railroad Track please come to the platform? The report of this Committee will be found in Bulletin 304, beginning on page 925, and will be presented by Dr. A. N. Talbot.

(For Report, see pp. 925-926.)

The President:—The report of the Committee on Wood Preservation will be presented by Mr. F. C. Shepherd, the Chairman.

(For Report, see pp. 707-748.)

The President:—Will the members of the Committee on Records and Accounts come to the platform? This report will be presented by Mr. J. H. Hande, Chairman of the Committee.

(For Report, see pp. 749-924.)

(Vice-President Louis Yager in the Chair.)

Vice-President Yager:—The report of the Committee on Buildings is found in Bulletin 304, beginning on page 927. The report will be submitted by Mr. Frank R. Judd, the Chairman.

(For Report, see pp. 927-965.)

(President D. J. Brumley in the Chair.)

The President:—The next item on the program is the report of Committee XXIV—Co-Operative Relations with Universities.

Mr. Robert H. Ford (Rock Island):—Although not in the printed record, a great deal of work has been done by the Committee on Co-Operative Relations during the past year. They are wrestling with a very difficult problem and that is to find some practical way whereby the railroads can constructively co-operate with our universities to the mutual benefit of both.

The Committee are in contact with various bodies, including the Society for the Promotion of Engineering Education, the American Society of Mechanical Engineers, and others.

The manner of employment and the diversifications of requirements for railway service, as well as the practical problems concerning centralization of employment as compared with the practices of other lines of industry, necessarily introduce complications.

I will say, however, that there is a great deal of hope for the future and I assure the Convention that this Committee hope to have something next year that will justify the absence of a definite report this year.

The President:—This completes the consideration of Committee Reports.

Before we proceed to the order of New Business, I should like to read to you the results of the registration this year compared with those of 1927 and 1926.

The total registration, including today, for this convention shows 968 members and 348 guests, or a combined total of 1316.

Last year there were 925 members, 346 guests, or a total of 1271.

In 1926, 831 members and 199 guests, or a total of 1030.

Apparently the registration at the meeting this year has established a new record in the history of the Association, being the first time in which the number of members registered has exceeded 950 and the total registrations have exceeded 1300. It is noted also that 37 per cent of the entire membership attended the meeting this year. (Applause.)

The next order of business is New Business. Under this heading I would like to ask if anyone has any resolution to offer, or anything to suggest for the good of the Association.

Secretary E. H. Fritch:—Mr. President, I have a resolution to offer.

"Resolved, That the members of the American Railway Engineering Association, in convention assembled, desire to place on record their hearty appreciation of the capable manner in which this convention has been presided over by Mr. D. J. Brumley, and for the efficient administration of the affairs of the Association during his occupancy of the Presidential Chair;

"That this resolution be spread upon the Minutes of the meeting, and a suitably engrossed copy presented to Mr. Brumley." (Applause.)

Vice-President W. D. Faucette:—Gentlemen, you have heard the motion by Mr. Fritch. It has been moved and seconded that this be accepted.

(The motion was carried unanimously.)

Vice-President Faucette:—Mr. Fritch will present Mr. Brumley with a copy, properly and duly executed.

The President:—Thank you very much, gentlemen.

Are there any further resolutions?

Mr. Earl Stimson (Baltimore & Ohio):—I wish to move the adoption of the following resolution:

"Resolved, That the American Railway Engineering Association, in convention assembled, does hereby express its appreciation for the untiring efforts and the sound business judgment with which he has conducted the affairs of his office to Mr. E. H. Fritch, our able and always genial Secretary." (Applause.)

(The motion was carried unanimously.)

Mr. F. J. Stimson (Pennsylvania):—I move the adoption of the following resolution.

"Resolved, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to Mr. L. A. Downs and John A. Rowland, Esq., for their excellent and instructive addresses at the annual dinner on the evening of March seventh."

(The motion was carried unanimously.)

Mr. W. H. Woodbury (Duluth & Iron Range):—I should like to offer this resolution:

"Resolved, By the American Railway Engineering Association in convention assembled that its appreciative thanks are hereby extended to the National Railway Appliances Association for the interesting exhibit of railway devices and appliances; to the management of the Palmer House and Mr. Juan Muller for the capable manner in which the convention was handled and courtesies extended to the members and guests."

I move the adoption of this resolution.

(The motion was carried unanimously.)

Mr. H. C. Crowell (Pennsylvania):—I should like to submit this resolution for adoption:

"Resolved, By the American Railway Engineering Association in convention assembled that its appreciative thanks are hereby extended to the Chairmen, Vice-Chairmen and members of the several committees for their labors during the past year and for the valuable reports presented to the meeting; to the technical and daily press and WJJD Broadcasting Station for broadcasting the addresses at the A.R.E.A. Annual Dinner on the evening of March 7th, and for the many courtesies extended during the year and during the convention."

I move the adoption of the resolution.

(The motion was carried unanimously.)

The President:—Are there any other resolutions? If there are no other resolutions or no further business to be transacted at this time, the Secretary will report the result of the election of officers for the ensuing year.

Secretary E. H. Fritch:—The result of the vote for officers is as follows:

President, W. D. Faucette; First Vice-President, Louis Yager; Second Vice-President, G. D. Brooke; Treasurer, F. J. Stimson; Secretary, E. H. Fritch; Directors, A. N. Talbot, Hadley Baldwin, F. E. Morrow; Members of Nominating Committee, T. T. Irving, F. W. Green, Maro Johnson, W. A. Clark, R. C. Bardwell.

The President:—I will appoint Past-Presidents J. L. Campbell and Edwin F. Wendt to escort President-elect Faucette to the platform.

(Past-Presidents J. L. Campbell and Edwin F. Wendt escorted President-elect Faucette to the platform.)

The President:—Mr. Faucette, one year ago today I was in the same situation you are in now. Our beloved President, Mr. C. F. W. Felt, stood on this platform and turned over to me the office of the Presidency of the American Railway Engineering Association. When he left the platform, it seemed to me that the task I had assumed was an enormous one, but as I looked over the audience I recalled that the American Railway Engineering Association was not composed of one individual, but there were 2510 other earnest men who were working with me. I assumed that all the 2510 would willingly devote as much of their time as was necessary to further the interests of the Association. In that respect I was not disappointed in a single instance.

In your case you have 2606 others who, I am quite sure, will be of as great use to you in your administration as the 2510 were to me.

It is with great pleasure I deliver to you the emblem of the office of the President of the American Railway Engineering Association. (Applause.)

(President W. D. Faucette took the Chair.)

The President:—Gentlemen of the Association: Mr. Brumley has stated the situation with regard to the work of this Association. Taking from him the cue of the way he has handled the Association and realizing the record he has made, it is with some difficulty to feel that I may approach what he has done. I am deeply sensible of the honor and responsibility required of this position. No sane man in his normal faculties can but feel an honor and a pride in being President of the American Railway Engineering Association. How far he may fall below the measure of his capabilities and equipment to discharge fully the duties of this position, pride is no fault, and no human being who has not the pride in this Association should be an officer thereof.

I know full well that with this Association of its 2600 odd members, I will receive, as have the Past-Presidents, full co-operation and full support. No executive can function successfully without that support that comes from the membership. The Board of Direction of this organization and its officers are part of you. They are the creation of your wishes and it is their intention and endeavor to carry out, honorably and aggressively, and endeavoring to keep the high plane of your standard, the duties which you have imposed upon them.

I may say we may fall far beneath your expectations, but realize that our motive is to do the right and proper thing. We are now entering upon a period of twelve months before we shall meet again. I think it is fair that I shall devote a few minutes to the method of administration that we have in our Association.

You have a Board of Direction, in whom I have the greatest faith and abiding confidence that they will keep me from many pitfalls. Due to the diversity of the geography of our membership, and the many and manifold duties that are assigned to these different committees, it is obviously impossible that one man can comprehend the activities of all. Therefore, in order to decentralize the control and place the work in the hands of responsible heads we have among the Board of Direction, a list of commit-

tees. I think you should know those I propose to place in charge of these several committees for next year.

May I add that if you have any suggestions, if you have any names, if you have any ideas, I should like to have them submitted to the Secretary or to the Chairmen of these committees. I will read them: The Board committees are as follows: The names of the activities of the committees are carried by their titles. I will only read the chairmanship:

Finance Committee: A Montzheimer, Chairman.
Publications Committee: Louis Yager, Chairman.
Library Committee: J. E. Armstrong, Chairman.
Outline of Work for Standing Committees for the Next Year: Robert H. Ford, Chairman; Past-President D. J. Brumley, Vice-Chairman.
Personnel of Committtees: J. V. Neubert, Chairman; G. D. Brooke, Vice-Chairman.
Special Committee on Manual: J. L. Campbell, Chairman.
Committee on Membership: G. D. Brooke, Chairman.

These men are from the Board of Direction of our Association. These men are selected with the full knowledge and belief in their capabilities and their full ability to direct the affairs of this Association.

I think it is only proper I should say to you there is one other committee not composed of members of the Board of Direction, but members selected by the Presidents and Past-Presidents until this Committee has grown to one of size and one of vast importance, and that is the "Committee on Arrangements for this Convention." On the Committee for next year we propose and I will appoint W. D. Simpson as Chairman, assisted by two other men, R. T. Scholes as Vice-Chairman and Second Vice-Chairman R. C. Bardwell.

To those men are entrusted the mass of details, and to them we owe, collectively and individually, our gratitude and our thanks for the covering of these several arrangements.

In conclusion, gentlemen, I wish to say, and I repeat, that I do not feel that I merit the honor that has been given me. I shall look forward to receiving and I know I shall receive your co-operation, support and help. It is the purpose of your Board of Direction and it is the purpose of your Chief Officer to carry on the work of this Association diligently and earnestly and we hope the standard that you have prescribed will be lived up to.

In closing, I wish to say that I render to you my hearty thanks and my full appreciation. (Applause.)

The new Board of Direction will convene immediately in Room No. 11 on the third floor of this hotel. The Chairmen and Vice-Chairmen, as you have had notice today, will also follow with their meeting immediately thereafter.

I now declare this convention closed and adjourned *sine die.*

(The thirtieth annual convention of the American Railway Engineering Association will be held at the Palmer House, Chicago, March 5, 6, 7, 1929.)

E. H. Fritch
Secretary.

COMMITTEE REPORTS

REPORT OF SPECIAL COMMITTEE ON STANDARDIZATION

W. C. Cushing, *Chairman;*
J. E. Armstrong,
C. W. Baldridge,
Hadley Baldwin,
W. C. Barrett,
*F. L. C. Bond,
W. J. Burton,
J. M. Farrin,
Robert H. Ford,
Paul Hamilton,
J. H. Hande,
W. E. Hawley,
J. C. Irwin,
*J. R. W. Ambrose, *Vice-Chairman;*
F. R. Judd,
*E. B. Katte,
C. R. Knowles,
*F. R. Layng,
B. R. Leffler,
F. E. Morrow,
J. V. Neubert,
W. M. Post,
A. N. Reece,
C. P. Richardson,
F. C. Shepherd,
Earl Stimson,
Committee.

*Members of the First Committee, 1919.

To the American Railway Engineering Association:

Your Special Committee on Standardization submits the following information as its annual report for the year 1927-1928:

WHY IS A COMMITTEE?

A member in Los Angeles sent in "Sparks," the "organ of the Electric Club," with the following marked item:

"Why Is a Committee?"

"But first, what is a committee?" A committee is a relatively small number of members of an organization which undertakes to perform a certain service for or on behalf of the whole organization.

"Often a committee appointment is regarded as an honor.

"But it isn't. Committee service is a job.

"Committees are appointed in the confidence that the functions for which the committee was created will be performed, faithfully and well. In accepting committee duty, the member gives his virtual promise that he will 'do his stuff'.

"When a committee fails to percolate, it has done a double injury to its organization. It leaves the work undone, in the first place, and stands in the way of any one else doing the work, in the second place. And to this may be added the blighting effect on the morale of the membership which results whenever the program of the organization is hindered or the obligations of officers and committees treated as of little importance and no binding quality.

"Fellow-members, when you accept official or committee obligation, in heaven's name, make good! Do the job, if possible. If you find that you can't, then step aside and clear the way for someone else.

"To fall down on the job is lamentable; but to lie down on the job is shameful and inexcusable."

In its annual report for the Association-year 1926-1927, the Committee discussed the problem of "Standardization," and submitted a plan for activity in making it workable.

The Board of Direction has graciously accepted the recommendation, and has made its own this:

Bulletin 300, October, 1927.

POLICY OF PROCEDURE CONCERNING "RECOMMENDED PRACTICES"

(A) The motive force of this Association is the Standard Committees and its organized effort by means of disseminated rather than by central concentration.

(B) A Standing Committee shall be the Continuing Sponsor of its own adopted "Recommended Practices," embracing the following duties:

(1) An annual review of each Manual-incorporated "Practice" with the recommendation for revision when found desirable.

(2) A Statistical Survey periodically to ascertain the extent of use by the Association members of the "Practice" under study.

(3) Selection of an "Association-adopted Recommended Practice" as worthy to be considered of "Mutual Interest" and importance to special industry and technical associations, or of national scope, coupled with an outline of its scope, a complete history of its development and a full statement of the extent of its use, for presentation to the Board of Direction with recommendation that it be submitted for co-operation with the bodies in which right of action has been vested. In the case of Industrial-and-Association-Mutual Interest the active body will be a co-operative committee or technical association, and in the case of National Scope, the American Engineering Standards Committee.

(C) The Board of Direction, after favorable action upon the recommendation of a Sponsor Committee, shall proceed as follows:

(1) In the case of Industrial-and-Association-Mutual Interest, authorize the Secretary to present the proposal to the interested body.

(2) In the case of National Scope, authorize the Secretary to request the approval and further action of the American Railway Association.

(D) The Special Committee on Standardization shall keep informed of the Rules of Procedure and general fields of activity of the associations and committees which may be considered to have interests in common with this Association, and shall be kept informed of the special co-ordinating recommendations of standing committees, in order to act as an Advisor to the Board of Direction.

(E) Attention has been called to the fact that sometimes several members from the Engineering Division have been designated to serve on the same sectional committee, American Engineering Standards Committee, without having any point of contact for concerted action. It is desirable, therefore, when these committee members are named by the Secretary of the American Railway Association, in the case of several being appointed, for the Secretary to name one of them to act in bringing them all together as may be considered desirable, in order to keep each other posted on the things which are being done and to enable them to decide on their mode of procedure.

These recommendations provide for a continuing organization for activity on the part of the Special Committee on Standardization, and as no additional instructions will be necessary no suggestions for future commands are made.

The work of the Committee for this year has been the collection of information relating to matters of "Recommended Practice" and "National Standardization," and the report is presented under those two captions.

PART I.—"RECOMMENDED PRACTICE"

The presentation of statistical information of the results of research work into scientific and technical problems, and of statements of variable practices of members concerning important details of construction and maintenance forms a large and important division of the activities of the Association in addition to the praiseworthy effort for the establishment of "Recommended Practice," and the elimination of waste in manufacture by simplifying the practice, thus bringing about reduction in stocks and forms, moulds, patterns and rolls.

At a meeting of the Committee, June 17th, the main discussion fell upon the distinction between standardization of materials and the impracticability of placing technical design in that category (Leffler).

The view was taken that technical design such as that of bridges, buildings, etc., should not be a subject of standardization, and sympathy with that view (Neubert) was expressed, but at the same time it was necessary to recognize that it was possible to come to a common understanding concerning certain features in connection with bridge and building design, and attention was called to the fact (Farrin) that standardization even in connection with bridges and buildings dealt with materials, their strength and use, rather than details of mechanical and engineering design.

Attention was called (Judd) to the fact that one of the useful lines of standardization work was the establishment of codes, both safety and structural. In certain cases, and particularly in the case of buildings which are built in many different cities under many different codes, these codes are so variable and contrary to each other that a building built under the code of one city should by rights fall down when built under the code of another city, and several cities were named, such as Memphis and Galveston, where such codes are markedly different. Several members stated (Baldwin) that a good deal could be accomplished by having more unified practice in connection with building codes, and the view also was expressed (Farrin) that the technical societies have a good influence in that work.

The outcome of the discussion was that this subject of technical design requires careful judgment in each case.

The field for simplification of general sizes, dimensions and styles, and for standardization in quality of materials and their application, with methods of conveying information in the case of country-wide use, is very large, and in the latter connection it was pointed out (Ford) that things having a very enlarged scope are the questions of highway crossing signs, efforts at simplification of which should be put forward at all times by members of the Association.

In dealing with the subject of national standardization it was pointed out (Anderson) that we need not be so concerned about the outside world as with our own internal work within the A.R.E.A. It was stated also (Barrett) that we should adhere to the policy already expressed of not attempting to place too many of the A.R.E.A. standards under the jurisdiction of the A.E.S.C. as being unnecessary and likely to arouse complications because of the almost exclusive interest of the A.R.E.A. in those particular

subjects. Unless a standard is really of national scope there would be no justification for putting it under the aegis of the A.E.S.C.

In this connection attention was called to the difficulty (Burton) had in the procedure of revising a national standard once established.

It was recognized also in this discussion that it is impossible to force the adoption of a standard by individual members of any association, but while it is recognized (Farrin) that the members of the A.R.E.A. should make the most use possible of the recommended practice of the Manual, nevertheless such use will not be made unless the recommended practice proves its own value for the purpose. No member will make use of practice recommended by a society, which as often happens is a compromise recommendation, unless its value is so outstanding that he will find it of great use to himself and his company, and, therefore, it is necessary in the preparation of reports and when requesting the adoption of recommended practice that the work be done with the utmost care and that after approval it be kept up to date constantly, and that is the work of each committee and its members. Some of the difficulties in connection with work of this kind were pointed out (Leffler) wherein it was stated that reinforced concrete dealers are constantly endeavoring to have the committee place their materials on the same basis as structural steel, while the steel dealer complains that concrete codes are entirely too favorable to that material, and another committee (Judd) finds that certain industrial agencies have been working against the idea of the building code.

It was also pointed out (Chairman) that there are three disturbing factors in the purchase of materials and supplies:

1. Interstate Commerce Commission requirements for an open market.
2. The inventor and manufacturer of proprietary articles.
3. The demands of shippers upon the Traffic Department of railways for reciprocal business.

Concerning the adoption of its "Recommended Practice" by the members of the A.R.E.A., an effort has been made by each Chairman of a committee to ascertain to what extent these recommendations have been made use of by the members of his own committee, and such information as has been forthcoming is cited below. There are three degrees of use for which the dogma of "Recommended Practice" are available, or adaptable for appropriation in one's own specifications or instructions:

1. Adoption verbatim, or nearly so, of the plans, specifications, instructions or rules.
2. Incorporation of the fundamental or main items of importance in settling upon and maintaining unification of methods.
3. Acceptance of the general influence of the data, and citations, in order that one's own practice may be in general accord.

From insufficient information it has been rather difficult to give the Association membership a complete view of the progress made in the effort for standardization and simplified practice. It is gratifying to learn of the degree of the value of the committee industry by answers like that of the Missouri Pacific—"Probably 70 percentum of standard plans, specifica-

tions and practices are American Railway Engineering Association or close thereto."

Committee I—Roadway

It can scarcely be expected that the "Recommended Practices" are used by everyone in accordance with the first degree, but it is probable that the observance is in accord with the reply of the Baltimore and Ohio—"Generally follow recommendations of Manual, in so far as our conditions will permit."

There are many useful hints in the 13 or more subjects treated, and they can be adhered to with advantage.

Committee II—Ballast

Information furnished by 47 railroads tells us that the "Recommended Practice" of the "Manual" is being used to the following extent, and presumably in the first degree above.

(1) Ballast Section for Gravel.....16 roads
(2) Ballast Section for Stone..... 12 roads
(3) Specifications for Stone Ballast.....17 roads
(4) Specifications for Washed Gravel Ballast..... 16 roads
(5) Using the Ballast Tests..... 14 roads

In addition, the Illinois Central and Baltimore & Ohio inform us that they are making use of the "Specifications for Ballast Tools."

Committee III—Ties

The "Specifications for Cross-Ties" and the "Specifications for Switch Ties" of this Committee have this year (1927) become a "National Standard" by approval of the American Engineering Standards Committee, Serial Designation 03-1926, so that the fact of general and almost universal use by the railways may be accepted.

It is probable, too, that the "Specifications for Dating Nails" are accepted by those whose practice is to make use of them.

Much of the work of this Committee has been that of keeping the Association members informed concerning the care, use and materials of cross-ties, especially frequent reports of the life-service record of ties of different kinds of wood and methods of preservation, and an annual statement of the facts of service given by ties of materials other than wood, as steel, and reinforced concrete, etc.

Keeping the Association members informed of subjects pertaining to their work is as valuable as the establishment of standards, when this information embraces:

> Cost-life statistical data.
>
> Details of the experimental use of materials and appliances, with conclusions established therefrom.
>
> Accounts of the manner of construction and cost of engineering structures, laboratory tests and studies dealing with the mechanics of materials.

The Pennsylvania Railroad has informed us that the "Specifications for Tie Plugs" have been accepted "in toto" as its own.

Committee IV—Rail

The 23 railroads represented on the Committee are:

1. Baltimore & Ohio
2. Nashville, Chattanooga & St. Louis
3. Santa Fe
4. Rock Island
5. Louisville & Nashville
6. Lehigh Valley
7. Norfolk & Western
8. Reading
9. Pennsylvania
10. Union Pacific
11. Northern Pacific
12. Missouri Pacific
13. Canadian Pacific
14. Canadian National
15. Boston & Maine
16. Illinois Central
17. New York Central
18. Southern Pacific
19. Wabash
20. Chesapeake & Ohio
21. Burlington
22. Chicago, Milwaukee & St. Paul
23. Lackawanna

The information concerning the use of "Recommended Practices" of the Rail Committee by its own personnel has been furnished by the first 14 listed. Only general statements can be made to illustrate the influence of each item:

Rail Sections.—The 90-lb. RA-A has been used by the Southern Pacific, Union Pacific, and with base modification by the Santa Fe.

The 100-lb. RE is being used by the Canadian Pacific.

The 110-lb. RE is being used by the Santa Fe, and Nashville, Chattanooga & St. Louis.

The 130-lb. RE is being used by the Lackawanna, Baltimore & Ohio, and Southern Pacific.

Rail Specifications.—With some modifications, more or less slight, the rail specifications are being used by a number of the railroads, those answering being the Nashville, Chattanooga & St. Louis, Pennsylvania, Santa Fe, Rock Island, Burlington, Louisville & Nashville, Lehigh Valley, Reading, and Baltimore & Ohio (without modification). It is pretty well known that this is but a small proportion of those making use of them.

Rail Drilling.—Only two have signified adherence to this, the Santa Fe for 110-lb. RE, and the Canadian Pacific for 100-lb. RE.

Drop Test Machine.—This is practically in universal use.

Specifications for Joint Bars, Heat Treated.—They are followed quite closely by the Baltimore & Ohio and Santa Fe, and the Reading without change.

Specifications for Track Bolts, Heat Treated.—They are followed quite closely by the Baltimore & Ohio and Santa Fe, and by the Nashville, Chattanooga & St. Louis and Reading without modification.

Rail Record Forms.—Certain of these forms are quite generally followed, principally the Track Foreman's Report of Rail Failures in Main Tracks. The Pennsylvania Railroad makes more extended use than any other company.

Specifications for Spring Washers.—There was no reply claiming use of these specifications, criticism being made in some cases that they are not deemed satisfactory.

Girder Rail Sections—Girder Rail Specifications.—These are both used by the Pennsylvania Railroad.

Several of the respondents replied that, while they did not always use the "Recommended Practices" in toto, they were used as the basis for their standards, and considered as a general guide for determination of practice

where conditions permitted. The work of the Association is considered especially beneficial in every line.

Committee V—Track

The track being the working partner of the wheel in carrying traffic, the "raison d'être" of a railroad, uniformity in design and interchangeability of appliances, so generally used by all, leads to greater economy, and the work of this Committee has been found to meet these requirements so well that the plans and specifications for frogs and switches, especially the manganese work, have been quite generally accepted. In addition, the designs for track spikes and track tools are quite widely used, the Baltimore & Ohio, Nashville, Chattanooga & St. Louis, Louisville & Nashville, Reading, Pennsylvania having replied to that effect. The Pennsylvania Railroad has adopted the Specifications for Steel Track Spikes "in toto," and they have also been made a tentative standard of the American Society for Testing Materials, Serial Designation A 65-26 T.

The information on "Maintenance of Line" and "Speeds of Trains Through Curves and Turnouts" are very useful to the members.

Committee VI—Buildings

The preparation of specifications for any single building is a laborious and difficult job, and therefore an examination of the "Specifications for Railway Buildings" will bring appreciation of the magnitude of the work done by this Committee, in addition to the preparation of skeleton designs for miscellaneous railway buildings, including details of roofs and flooring.

The Baltimore & Ohio and Seaboard Air Line have informed us that they work along the same lines.

Committee VII—Wooden Bridges and Trestles

The "Grading Rules and Classification of Timber and Lumber for Railway Uses" is an outstanding contribution of valuable information by this Committee, to which the economical comparison of the "Merits of Ballast Deck and Reinforced Concrete Trestles" is a good second. The former of these has become a national task in co-operation with other societies and the industry. In October, 1922, the "Central Committee on Lumber Standards" was set up by the "lumber industry" under the leadership of the U.S. Department of Commerce and comprises men appointed by different interests to represent their side of the industry in establishing standards of grade, size and methods of conduct of the business. The resulting standards have been printed in Simplified Practice No. 16. Wm. E. Hawley was chosen by the American Railway Association to represent the railroads and he is Vice-Chairman.

Committee VIII—Masonry

The "Specifications for Portland Cement" have been made a "National Standard" by adoption of the American Engineering Standards Committee, Serial Designation A1-1922, through the co-operation of engineering societies and industry with the American Society for Testing Materials as sponsor, and have been almost universally adopted in concrete construction everywhere.

The preparation of "Specifications for Concrete, Plain and Reinforced" likewise has become a work of co-operation between engineering bodies, the American Society for Testing Materials and the U.S. Bureau of Stand-

ards being leaders. Many of the "Methods of Test" for aggregates employed in concrete making have become national standards by adoption of the American Engineering Standards Committee with the American Society for Testing Materials as sponsor. The Illinois Central, Union Pacific, and the Pennsylvania Railroad have informed us that they have become their standards, and the latter company has also adopted the "Specifications for Billet-Steel Reinforcing Bars," American Society for Testing Materials, Serial Designation A 15-14.

Committee IX—Grade Crossings Design, Protection and Elimination

Prior to the annual convention of 1927, this was the Committee on "Signs, Fences and Crossings."

Two of the most useful "Recommended Practices" are the "Specifications for Right-of-Way Fences" and the "Specifications for Concrete Fence Posts." The Pennsylvania Railroad reports that it has made both of them its own, though they have been written in different form.

Committee X—Signals and Interlocking

This is really the Signal Section of Division IV—Engineering, of the American Railway Association, and its recommended practice is not republished in the Proceedings, American Railway Engineering Association. It is believed, however, that the principles established are generally in use by the railways.

Committee XI—Records and Accounts

The Track Chart of the Committee is in use by the Pennsylvania Railroad and probably by others, though the information has not been given.

A very complete set of "Conventional Signs for use on Railway Profiles and Architectural Details" has been approved by the Association, and the Committee has provided the members with a set of "Engineering Department Forms," "Specifications for Maps, Charts, and Profiles," forms for "Statistical Records," and an explanation of "Cost-Keeping Methods."

The following projects have been undertaken through Sectional Committees by the American Engineering Standards Committee:

Z 10 Scientific and Engineering Symbols and Abbreviations.

Z 14 Standards for Drawing and Drafting Room Practice.

G. R. Walsh is our representative on both.

Committee XII—Rules and Organization

Many "Recommended Practices" have been established by this Committee, but no information concerning extent of use by its members has been furnished. The nature of the work makes it laborious and difficult.

Committee XIII—Water Service

The Illinois Central has adopted the "Specifications for Cast Iron Pipe and Special Castings," and the "Specifications for Hydrants and Valves," and the Baltimore & Ohio in proposed new work makes use of the method of calculating economies of water treatment. Specifications for the chem-

icals for several water softeners have been provided, and also "Specifications for Wooden Water Tanks and Timber Substructures," and "Specifications for Steel Water and Oil Tanks," the "General Principles of Water Supply Service" with proposed "Organization" and "Water Service Records."

Committee XIV—Yards and Terminals

The "Track Scale Specifications" appearing in the 1921 Edition of the Manual may be considered as belonging in the first degree, as they are the standard track scale specifications throughout the United States for both railways and industrial concerns, being also published in pamphlet form, Circular No. 83, by the U.S. Bureau of Standards.

It is reported that some 750 track scales have been set up in conformity with these specifications.

In addition, other portions of the scale sections of the Manual, particularly the portion devoted to rules for their location, maintenance, testing and operation, have been the basis for the adopted practice of various railways.

The Manual information comes in general under the headings of Passenger Terminals, Freight Terminals, and Scales, and that under the two first consists essentially of principles and other general information which may be used as a guide.

Important studies of yard design and operation have been made by the Committee.

Committee XV—Iron and Steel Structures

The Baltimore & Ohio, Rock Island and Union Pacific use the "General Specifications for Steel Railway Bridges" as a basis for their own. This is a large and important work, and has been made the basis of Project A-3-a of the American Engineering Standards Committee with this Association as sponsor.

Two other great works are "General Specifications for Steel Turntables" and "Specifications for Movable Railway Bridges." The latter are the most recent and complete for such structures and are used to a large extent by those engaged in this class of design. The specifications have been recommended to the American Engineering Standards Committee for adoption as a "National Standard" by the American Railway Engineering Association as sponsor, and the subject is now Project A 25.

Committee XVI—Economics of Railway Location

Profound mathematical study is involved in this subject, and examination into the mechanics of the locomotive has been necessary with consideration of its power from fuel and water consumption, together with the effect on this power of resistance from grade, curvature and rolling stock, dissertations on each of which have been given.

Committee XVII—Wood Preservation

The "Specifications for Creosote Oil" (different grades), the "Methods of Analyses," and the "Specifications for the Preservative Treatment of

Wood" may be confidently said to be in general use. A great deal of valuable information has been given by the Committee.

Committee XVIII—Electricity

Doubtless much of this "Recommended Practice" is being used in one way or another by the Association members, as the specifications and information are very useful, profound study of technical physics and mechanics being required.

The "Specifications for Electric Light, Power Supply, and Trolley Lines Crossing Railways," and the "Specifications for Maintenance of Overhead Electric Supply Lines" should be used by all of us, and, in the event of the National Electrical Safety Code (Project C 2-1922 A.E.S.C.) being approved for "National Standard," it will be desirable to have our interests amalgamated in order to avoid confusion, which means money waste. This latter is about to receive the approval of the American Engineering Standards Committee.

The Pennsylvania Railroad informs us that it has incorporated in its "Letters of General Practice" the "Rules for Recommended Practice Relative to the Protection of Oil Sidings from Danger Due to Stray Currents," a most useful guide.

All members in electrical territory will find the "Overhead Clearance Lines for Permanent Way Structures on Electrified Railways" valuable for reference.

The several "Specifications for Friction Tape, Adhesive Tape, Rubber Insulating Tape and Porcelain Insulators for Railroad Supply Lines" are being used by some.

Important information is given in the "Tables of Curves and Conductor Sags" and the graphical representation.

Committee XX—Uniform General Contract Forms

Only one of the members of the Committee gave any specific information to the Chairman on the use of the Committee's own "Recommended Practice" concerning uniform general contract forms. Mr. E. L. Taylor, Assistant to Vice-President, New York, New Haven & Hartford R. R., stated that—"the forms are of substantial value as a guide to good practice," and—"they use the A.R.E.A. Standard Contract Forms in so far as they conform to requirements."

This Committee has provided the members with advantageous information about 16 forms suitable for bases of agreements concerning railroad operation.

Committee XXI—Economics of Railway Operation

There is much difficulty in obtaining reliable data for studies of this subject, but three important contributions have been made by the Committee for the benefit of the members: "A Formula or Method of Calculating the Cost of Moving Freight Traffic," a "Method for the Determination of Proper Allowances for Maintenance of Way Expenses due to Increased Use and Increased Investment," and "Methods of Analyzing Costs for the Solu-

tion of Special Problems, including the Study of the Costs of Starting and Stopping Trains."

In addition the Chairman, James M. Farrin, has provided the Association with an excellent and useful brochure entitled "Economics of Railway Track."

Committee XXII—Economics of Railway Labor

The same difficulty of obtaining reliable data for studies appertains in this subject, but three important studies have been made: "Standard Methods for Performing Maintenance of Way Work for the Purpose of Establishing Units of Measure of Work Performed," "Extent to which it is Practicable to Stabilize Employment in the Maintenance of Way Department in the Interest of Efficiency, and the Necessary Measures Thereto," and finally "Methods of Maintaining Motor Cars."

Committee XXIII—Shops and Locomotive Terminals

The subjects of "Engine House Design," "Ashpits," "General Layout and Design of Passenger Car Shops," "Recommended Practice for Freight Car Repair Shops" and principles relating to "Fuel Oil Stations" have been reported, but it is not known to what extent the principles are in use.

Committee XXIV—Co-Operative Relations with Universities

A liaison committee between the Universities where our professional education began, and the Railways where the application of the fact and theories is made, for the purpose of maintaining this relationship as perpetual graduate students, and imparting the knowledge of practical experience to the army of cadets, in order that their vision may be directed to the advancing importance of the economic problem of transportation to the growing mass of population may be considered a general concept of its origin.

Its task is so *abstract,* that putting it through the *concrete* mixer will be most difficult, but until that is done, it will not occupy space in the "Manual." A beginning towards the collection of *aggregates* has been made in the preparation of a "Questionnaire on the Employment and Training of College Graduates in Railway Service."

PART II—"NATIONAL STANDARDIZATION"

The A.R.E.A. liaison with National Standardization is by membership of the American Railway Association as one of the twenty-four Member-Bodies forming (1927) the American Engineering Standards Committee as shown in the 1926-1927 report of your Committee.

The Membership Representative is Division IV—Engineering, subdivided into three sections:

(1) Construction and Maintenance Section (American Railway Engineering Association).
(2) Electrical Section.
(3) Signal Section.

The accredited members of the Divisions assigned to service on the American Engineering Standards Committee to the end of the year 1927 are:

Representative: *W. C. Cushing, Engineer of Standards,
The Pennsylvania Railroad,
607 Broad Street Station, Philadelphia, Pa.

Alternate: J. R. W. Ambrose, Chief Engineer,
Toronto Terminals Railway,
Toronto, Ontario, Canada.

Alternate: J. E. Saunders, Signal Engineer,
Delaware, Lackawanna & Western Railroad,
Hoboken, N. Y.

The American Railway Association has seven Divisions and several Special Committees for carrying on its operating and technical work, as follows:

†Division I—Operating.
Telegraph and Telephone Section.
Committee on Grade Crossing Protection and Trespassing.
Division II—Transportation.
Division III—Traffic.
†Division IV—Engineering.
Construction and Maintenance Section.
Electrical Section.
Signal Section.
†Division V—Mechanical.
†Division VI—Purchases and Stores.
Division VII—Freight Claims.
Several Special Committees.

The four Divisions marked (†) are really interested in standardization and simplification of practice, but Division IV has the only membership representative.

Nevertheless, quite a number of the men of these several Divisions are serving on Sectional Committees of the American Engineering Standards Committee and assisting in other ways.

Of the two hundred and thirty-eight projects having official status, the American Railway Association and the American Railway Engineering Association have accredited representation officially co-operating in the Sectional Committee work of projects as folows:

(Revision)	A 1	—1922—Portland Cement, Specifications and Tests for.
	A 3	—Bridges, Steel.
	‡A 3a	—Bridges, Steel Railway, General Specifications for.
	A 4	—Shapes, Structural Steel.
	A 21	—Pipe, Cast Iron, and Special Castings, Specifications for.
	A 22	—Walkway Surfaces, Safety Code for.
	‡A 25	—Bridges, Movable Railway, Specifications for.
	A 35	—Manhole Frames and Covers.
	A 36	—Rating of Rivers.
	B 16	—Pipe Flanges and Fittings.
	B 18	—Bolt, Nut and Rivet Proportions.
	B 20	—Conveyors and Conveying Machinery, Safety Code for.

*Member of Executive Committee also.
‡Denotes the Projects for which American Railway Engineering Association is *Sponsor.*

(Revision)	C 2 —1922—	Electrical Safety Code ("National Electrical Safety Code").
	C 4	—Power Control, Electrical, Safety Code for.
	C 5	—Lightning, Code on Protection Against.
	C 7	—Rating of Electrical Machinery.
	‡C 8	—Wires and Cables, Insulated (Other than Telephone and Telegraph).
(Approved)	C 10—1924—	Symbols for Electrical Equipment of Buildings.
(Approved)	C 11—1927—	Aluminum Conductors, Hard Drawn, Standards for. (In Press.)
	C 18	—Dry Cells.
(Approved)	C 19—1925—	Control Apparatus, Industrial. (Electrical.)
	C 20	—Line Insulators for Voltage not Exceeding 750.
	C 23	—Direct-current Rotating Machines, Standards for.
	C 24	—Alternators, Synchronous Motors and Synchronous Machines in General, Standards for.
	C 25	—Induction Motors and Induction Machines in General, Standards for.
	C 26	—Fractional Horsepower Motors, Direct—and Alternating—Current, Standards for.
	C 29	—Power Line Insulators for Voltages Exceeding 750.
	D 3	—Colors for Traffic Signals, Safety Code for.
(Approved)	E 8 —1926—	Rail, 7-inch, 82-lb. Plain Girder for use in Paved Streets, Recommended Designs for.
(Approved)	E 9 —1926—	Rail, 7-inch, 92-lb. Plain Girder for use in Paved Streets, Recommended Designs for.
	E 10	—Trackwork, Special Materials for use in the Manufacture of, Specifications for.
(Approved)	E 11—1926—	Rail, 7-inch, 102-lb. Plain Girder for use in Paved Streets, Recommended Designs for.
	G 8	—Zinc Coating of Iron and Steel, Specifications for.
	G 15	—Steels, Numbering of.
(Approxed)	‡O 3 —1926—	Ties, Railroad, Specifications for. (In Press.)
	O 4	—Wood, Methods of Testing.
	O 5	—Poles, Wood, Specifications for.
(Revision)	X 2 —1922—	Heads and Eyes of Industrial Workers, Safety Code for the Protection of.
	Z 4	—Sanitation, Industrial, Safety Code for.
	Z 10	—Scientific and Engineering Abbreviations and Symbols.

The American Railway Engineering Association is the sponsor for four projects only, one of which has been adopted and in press, while the American Society for Testing Materials is sponsor for fifty-five and the Bureau of Standards for thirteen.

It would be desirable to add to the above list of projects the names of the A.R.A. delegates serving on them, but complete and accurate information is not available at present.

There will be no presentation this year by the American Railway Association of projects for approval as American Standards by the American Engineering Standards Committee.

An attempt has been made to ascertain the names of Standing Committeemen of the American Railway Engineering Association who are serving as members of Sectional Committees of the American Engineering Standards Committee, and in other co-operating societies, as it was realized

that it would be impractical to obtain that information from the full membership of the American Railway Engineering Association, and still more so from the American Railway Association. Even so, complete information has not been forthcoming, but it is hoped that the partial roster submitted will lead to complete information in a future report.

MEMBERS OF A.R.E.A. STANDING COMMITTEES SERVING AS MEMBERS OF A.E.S.C. SECTIONAL COMMITTEES AND ON COMMITTEES OF CO-OPERATING SOCIETIES

No. of Committee and Name of Member	American Engineering Standards Committee Project	
II—Ballast	None	None
IV—Rail		
E. Stimson	•	A.S.C.E. Joint Special Committee on Stresses in Track with A.R.E.A.
E. E. Adams	B 18—Bolt, Nut & Rivet Proportions (Design of Track Bolts).	•
F. L. C. Bond	•	Canadian Engineering Standards Association.
E. E. Chapman	•	A.S.T.M. Steel Committee Cast Iron, Wrought Iron and Malleable Iron Committees.
W. C. Cushing	Representative of A.R.A., Division IV, Engineering. B 18—Bolt, Nut and Rivet Proportions (Sub-Comm. IV, Track Bolts & Nuts).	A.S.T.M. Comm. A-1, on Steel (Sub-Comm. 1). A.S.C.E. Joint Special Comm. on Stresses in Track, with A.R.E.A.
J. M. R. Fairbairn	•	Canadian Engineering Standards Assoc. Member General Comm. & Chairman Comm. Rails & Track.
C. R. Harding (Also V Track)	•	A.S.C.E. Joint Comm. Specifications for Steel Ry. Bridges with A.R.E.A.
G. J. Ray	•	A.S.C.E .Director. Joint Special Comm. on Stresses in Track with A.R.E.A.
C. P. Van Gundy	G 8—Zinc Coating of Iron & Steel, Specifications for.	A.S.T.M. Comm. A-1 on Steel. Comm. A-2 on Wrought Iron. Comm. D-1 on Preservative Coatings. Comm. D-2 on Petroleum Products.
F. M. Waring		A.S.T.M. Comm. A-1 on Steel. Comm. A-2 on Wrought Iron. Comm. D-11 on Rubber.
J. B. Young	•	A.S.T.M. Comm. A-1 on Steel. Comm. A-2 on Wrought Iron. Comm. A-3 on Cast Iron. Comm. D-1 on Paint. Comm. E-5 on Standing Comms. Comm. E-8 on Nomenclature & Definitions.
V—Track	•	
J. V. Neubert	B 18—Bolt, Nut & Rivet Proportions.	Roadmasters & M. of W. Association.
E. W. Caruthers		A.S.M.E. Cranes, Derricks & Hoists. Chairman Sub-Comm. 7 on Jacks.
E. B. Entwistle	•	Amer. Elec. R. R. Engr. Assoc.
E. T. Howson (Also XXII Economies of Railway Labor)	•	Amer. Ry. Bridge & Bldg. Assoc. Roadmasters of M. of W. Assoc. A.S.T.M.

No. of Committee and Name of Member	American Engineering Standards Committee Project	
J. B. Myers	B 18—Bolt Nut & Rivet Proportions.	*
O. C. Rehfuss	*	Manganese Track Society Standardization Comm. Amer. Elec. R. R. Engr. Assoc. (Sub-Comm. 7).
J. B. Strong	*	A.S.T.M. Amer. Elec. R. R. Engr. Assoc.
VI—Buildings		
G. A. Rodman	*	Amer. Ry. Brdg. & Bldg. Assoc. (Protection of Men Working Under Traffic.) U. S. Nat. Comm. on Wood Utilization.
W. T. Dorrance	A 22—Walkway Surfaces, Safety Code for. A 35—Manhole Frames & Covers O 4—Wood, Methods of Testing. Special Comm. Screw Threads for Hose Coupling.	*
A. T. Upson	O 4—Wood, Methods of Testing. A 14-1923—Ladders, Safety Code for.	A.S.T.M. Comm. D-7. Timber.
VII—Wooden Bridges and Trestles		
W. E. Hawley	*	Central Comm. on Lumber Standardization.
C. J. Hogue	*	A.S.T.M. Comm. D-7.
J. A. Newlin	*	A.S.T.M. Comm. D-7 Sec'y Comm. D-10 Chair. U. S. Dept. Commerce Building Code.
C. E. Paul	*	A.S.T.M. Comm. D-7.
J. L. Vogel	*	Am. Concrete Inst. Comm. S2.
VIII—Masonry		
J. F. Leonard J. J. Yates M. Hirschthal	A 1-1922 Portland Cement, Specifications and Tests for	A.S.T.M. Comm. C-1 on Cement.
XIV—Yards & Terminals		
J. R. W. Ambrose	Alternate Representative of A.R.A., Division IV—Engr.	*
J. E. Saunders	Alternate Representative of A.R.A., Division IV—Engr.	
XV—Iron & Steel Structures		
O. F. Dalstrom, Ch. O. E. Selvy I. L. Simmons F. E. Turneaure	A 3a—Bridges Steel Ry., General Specifications for.	*
J. B. Hunley, Ch. A. Reichmann O. E. Selby	A 34—Bridge Superstructure, Steel Highway, Specifications for Design and Construction of.	*
XVII—Wood Preservation		
H. von Schrenk	O 5—Poles, Wood, Specifications for.	A.S.T.M. Comm. D-7, Ch.
E. B. Fulks		A.S.T.M. Comm. D-7. (Sub-Comm. Determination Moisture in Wood.) (Sub-Comm. Wood Preservation.)
XVIII—Electricity		
E. B. Katte	Electrical Advisory Comm. C-8—Wires & Cables, Insulated. (Other than Telephone and Telegraph.) C 23—Direct Current Rotating Machines. Standards for. (Amer. Inst. of Elec. Engrs.)	*

No. of Committee and Name of Member	American Engineering Standards Committee Project	
Cont.		
XVIII—Electricity		
L. S. Billau	C 8—Wires & Cables. Insulated (Other than Telephone & Telegraph)	Assoc. of Ry. Electrical Engineers Comm. on Illumination.
	Alternate Representative Assoc. Ry. Elec. Engrs. (Tech. Comm. 10, Standard Makeups for Rubber Insulated Wires.) (Tech. Comm. 12, Weatherproof, Heat Resisting & Similar Wire & Cables.)	
J. H. Davis	*	Amer. Elec. Ry. Assoc. Comm. on Heavy Elec Traction.
C. L. Doub	*	Amer. Elec. Ry. Assoc. Power Special Comm. No. 2 on Mercury Arc Rectifier.
J. S. Hogan	*	Amer. Inst. of Elec. Engrs. Comm. on Protective Devices.
F. D. Hall	C 29—Power Line Insulators for Voltages Exceeding 750. C20—Line Ins lators for Voltage not Exceeding 750.	*
C. B. Martin	C 8—Wires & Cables, Insulated (Other than Telephone & Telegraph).	A.S.T.M. Comm. D-11, Rubber Products.
J. L. Minick	*	Assoc. of Ry. Elec. Engrs. Comm. on Illumination.
W. L. Morse	C 2—Electrical Safety Code. (National Electrical Safety Code), 1922 Revision of Parts 2 & 4.	*
R. J. Needham	A 36—Rating of Rivers.	
W. M. Vandersluis	*	United States National Comm., International Electro-technical Commission. Comm. of Advisors on Rules & Regulations for Overhead Lines.
L. S. Wells	C 2—Electrical Safety Code (National Electrical Safety Code) 1922 Revision of Parts 1 & 3, and Section 9. C 8—Wires & Cables, Insulated (Other than Telephone & Telegraph). Sub-Comm.'s Railway Equipment Fibrous Wire Coverings. Tech. Comm. 12, Weatherproof, Heat Resisting & Similar Wires & Cables.	Amer. Elec. Ry. Assoc. Comm. on Heavy Elec. Traction.
G. C. Winslow	C 26—Fractional Horse Power Motors, Direct- and Alternating Current, Standards for.	
Sidney Withington	C 25—Induction Motors & Induction Machines in General, Standards for.	Nat. Elec. Light Assoc. Comm. on Electrification of Steam Railroads.
	Electrical Advisory Comm., Alternate.	Amer. Inst. of Elec. Engrs. Comm. on Transportation.
	C 8—Wires & Cables, Insulated (Other than Telephone & Telegraph).	Comm. No. 42 Recommendations for International Standards on Railway Motors.
	Technical Committees: No. 5, Impregnated Paper Cable No. 12, Weatherproof, Heat Resisting & Similar Wires & Cables.	U. S. National Comm. International. Electrotechnical Commission. Comm. of Advisors on Traction Motors.
J. V. B. Duer	*	Amer. Elec. Ry. Assoc. Comm. on Heavy Electric Traction.
J. C. Davidson	*	Amer. Elec. Ry. Assoc.
A. H. Woollen	*	Amer. Elec. Ry. Assoc. Comm. on Heavy Electric Traction.
XX—Uniform General Contract Forms	None	None
XXII—Economies of Railway Labor		
A. N. Reece	*	A.S.T.M.

The American Engineering Standards Committee has been studying for some time two very important changes, (1) a revision of the constitution with the object of strengthening the hands of the organization in order to speed up the machinery, and (2) membership in a central body of co-ordinated groups in control of international standardization.

Since the first question was opened, there has developed quite a movement for making the Committee a real national standardizing body, rather than a co-ordinating committee as it is now. At the same time, Mr. Morrow of the *Electrical World* has been writing editorials in favor of a standardizing body under executive control of governmental agencies and your official representative on the American Engineering Standards Committee was invited by a member of the Constitution Revision Committee to express his views, which he did after careful preparation, and, on account of the information given therein, and the general review of the work of standardization, it is made a part of this report, as follows:

"I had already read Mr. Morrow's article from the *Electrical World,* which I was enabled to do through our A.E.S.C. headquarters before the receipt of your letter of May 27th.

"I am glad indeed to have this letter, together with the copy of letter to Mr. Morrow, as it calls attention to several things about which our reasoning has been much confused, owing, we might say, to the particular point which seems to have impressed Mr. Morrow, viz., "Multiplicity of Agencies," and which subject indeed I do not think he has handled with entire clear vision or he would not be proposing a hypothetical organization for executive control by governmental agencies, and which you have ably criticized in your letter.

"There are two subjects before us:

1. A revision of the constitution of the A.E.S.C.
2. A proposed international alliance.

"I have always endeavored to keep these two subjects entirely separate in discussing them, but it is very difficult to do and most of us are inclined to argue about them indiscriminately.

"My letter of May 24th, to Dr. Agnew, which I find he has circulated, was intended to deal only with the international question with the object of trying to withhold celerity of action before the subject had been sufficiently examined into and understood at home.

"I have also been mulling over the question of standardization in our own country in order to offer helpful criticism rather than only destructive criticism and have come to the conclusion in my own mind that there are several ideas which may be considered fundamental in this problem and that settling them for our own conditions in this country will help us to settle the question of international relationship.

"I may, therefore, consider your letter as an invitation to set down some of these thoughts, which I now do.

Thoughts on Standardization

"1. The active energetic and working forces for standardization anywhere are:

(a) The numerous trade associations, each of its own kind, a good representative being the Society of Automotive Engineers.

(b) The Technical societies, managed and dominated by the users of materials, appliances and manufactured articles of all kinds, such as Division IV—Engineering, and Division V—Mechanical, of the American Railway Association.

(c) The technical societies, combining the interests of both (a) and (b), best represented by the American Society for Testing Materials.

"I might place government engineering bureaus under (c), for it has activities both in manufacturing and from the users' standpoint also, but inasmuch as it does not manufacture for public use, they can best be classed under (b).

"The national engineering societies are considered as representing both the field of pure and applied science, and the strength of materials as concerned with the high problems of construction work of all kinds. They are generally of the nature of a forum for the presentation and discussion of their general principles and problems requiring research in relation to their own field, generally divided into four great societies, Civil, Mechanical, Electrical and Mining.

"All of these organizations are the working forces in these various fields and have been originated because their problems extend over a wide field and are of mutual interest to large bodies of men. *They will always hold this position.*

"2. Some of the agencies discussed above have found themselves interrelated in some respects with other agencies, and they have, therefore, joined themselves together into groups of their own kind, such as the Electrical Group, the American Society for Testing Materials representing both users and manufacturers with the avowed object of placing methods of testing on a standard basis, a work of the greatest importance, and another is the Railway Group, working under the aegis of the American Railway Association, embracing seven Divisions, I—Operating, II—Transportation, III—Traffic, IV—Engineering, V—Mechanical, VI—Purchases and Stores, and VII—Freight Claims.

"Probably the greatest combination of all has been brought about within the government service itself by the union of many of its engineering divisions into the Federal Specifications Board and several other co-operating agencies within the different departments. The government is a great user of materials, appliances and articles of all kinds and organization of this kind is undoubtedly of the greatest value.

"These various agencies are listed more or less completely in Standards Year Book, 1927, of the U.S. Department of Commerce; from page 307 to page 387 are listed a large number of these active working standardizing bodies of which I have spoken, and in other parts of the Year Book are given more completely an idea of the multitude of government bureaus having more or less to do with these subjects.

"3. The cross-currents of interest between all of these different organizations have become more numerous, crooked and diverse, so that the next step is to bring the many groups into a harmonious and instructive relationship with each other.

"A perusal of the list will show that all of these groups can never be brought together, as the interests of many of them are so utterly different from the others that there is no relationship between them. There will thus be several different organizations in a country of national scope whose object will be to co-ordinate the various working agencies in which they are severally interested, and it is my understanding the American Engineering Standards Committee was organized to act in that capacity for technical engineering bodies. It should, therefore, have a definite engineering field and not attempt to spread over all the interests in which it is not materially interested. It has no great interest in the standardization work of the Department of Agriculture for instance, except in so far as the Department of Agriculture has within its jurisdiction the Bureau of Public Roads and the Forest Products Laboratory.

"It seems to me, therefore, that the first course of procedure is to have in view a fairly well fixed scope of activity for the A.E.S.C.

"For the above reason I am opposed to the proposed new name American Standards Association, as it is entirely too unrestrictive and does not appear to me to indicate on its face the real work of the A.E.S.C. I believed the word 'Engineering' belongs in the name.

"It is evident from what has already been said that there are other organizations besides that A.E.S.C. claiming work of national scope and which are not affiliated with the A.E.S.C.

"It seems to me, therefore, that the A.E.S.C. is already formed on the correct basis of being a co-ordinating body only and can never become in itself a maker of standards. That work will always be done by the active agencies referred to in No. 1, and some of those standards being of limited application never will be referred to the A.E.S.C. It is only those of widespread use between inter-related associations and bodies which will or should be referred to the A.E.S.C. Examples of the kind mentioned are the Cement Specifications, the Cross-Tie Specifications, etc.

"It is unfortunate that the word 'Committee' has been used in the A.E.S.C. organization to mean so many different kinds, but confusion can be eliminated either by changing the word 'Committee' in the name, or which will answer the purpose just as well, by altering the names of its other uses, as, for instance, the 'General Committee,' which is not a good one anyhow.

"4. We have not arrived at international relationship and we find the following already in the field listed in Standards Year Book, 1927, of the U.S. Department of Commerce, pages 9 to 19:

Non-governmental—

International Astronomical Union.
International Commission on Illumination.
International Electrotechnical Commission.
International Union of Pure and Applied Chemistry.
Commission on Pure Products for Research Analytic Reagents.
International Commission on the Chemical Elements.

and several hundred national associations for the most varied purposes.

"One of these, the Electrotechnical Commission, which already has a representative in this country in the Institution of Electrical Engineers through a special committee organized for the purpose, known as the U.S. International Committee, and this international organization has proposed that the A.E.S.C. be taken into it as a part of it.

"As explained in my letter to Dr. Agnew, May 24th, it has not been made clear to me that this will be an advantageous relationship, and I believe it will require a great deal further consideration before we can agree that it is or will be an advantageous relationship. We must know something of the influence and working of the I.E.C. in foreign countries in relationship to other engineering standardizing bodies before that point can be settled. After that has been settled then it will be time enough to proceed with the details of union.

"In this union there should be no double representation. All associations which co-ordinate through the A.E.S.C. should have their representation in that body only.

"This letter is a great deal longer than I intended when I started, and you are at liberty to make such use of it as you desire with the membership of the A.E.S.C."

Yours very truly,

W. C. Cushing,

Representative, American Railway Association Engineering Division.

The extent of the standardization work of the U.S. Department of Agriculture will probably be surprising to many. One bureau only, the Bureau of Agricultural Economics, has an annual appropriation of approximately $5,000,000, of which $2,000,000 is spent in research and general educational work in connection with standardization of agricultural products.

In the year 1916, Congress passed two compulsory standardization laws, one in regard to cotton and one in regard to grain, and also two others that affect standardization—the U. S. Warehouse Act, and the U. S. Standard Container Act. "Congress gave to the Bureau the authority to establish standardized grades of grain which were to be mandatory for all grain shipped in interstate commerce. The U.S. Grain Standards Act is, even today, the most far-reaching compulsory act regarding agricultural standardization that we have on the books. Not only must every shipper who wishes to ship grain out of his state use the grades established by the Bureau under this Act, but he must also undergo supervision, must secure an inspection of his carload of grain, and have a written certificate which is the basis of the transaction between buyer and seller. The government, so far as the grain business is concerned, has a close contact with the business of marketing grain. No car can be moved across any state line until a certificate of inspection is obtained from the Department of Agriculture through the Bureau, now the Bureau of Agricultural Economics.

"Cotton was somewhat similarly dealt with, but no certificate is required. The standards must be used, but anyone can buy and sell unless found in a misuse of the standard. There is one exception. When a future shipment is delivered against contract, the goods must be examined and inspected by the Bureau."

*In order to give an idea of the extent of the activity of the Division of Simplified Practice, the accompanying statement is taken from the report of the Chief, Ray M. Hudson.

As the work of this Committee is largely that of dissemination of information concerning progress in the efforts for standardization, no recommendations are made.

Respectfully submitted,

Special Committee on Standardization,

W. C. Cushing, *Chairman.*

*Since this was written, Mr. Hudson has been appointed Asst. Director, Bureau of Standards, in charge of a new sub-division carrying the name of Commercial Standards. Apparently it will be the successor of the Division of Simplified Practice, thus raising its standing and importance by placing its direction in the Bureau of Standards.

U.S. DEPARTMENT OF COMMERCE—DIVISION OF SIMPLIFIED PRACTICE—STATEMENT OF PROGRESS IN ELIMINATION OF WASTE BY REDUCTION IN VARIETIES OF ARTICLES UP TO SEPTEMBER 15, 1927.

NOTE: Publications are available for all items on following list except those indicated by (*) and may be obtained from the Superintendent of Documents, Government Printing Office, at the price shown. Do not send stamps.

SPR No.	Item		Price Reduction in Varieties From	To	Per Cent Reduction
1.	Vitrified Paving Brick				
	Fourth Revision Conference	5c	66	4	94
2.	Beds, Springs and Mattresses	5c	78	4	95
3.	Metal Lath	5c	125	24	81
4.	Asphalt (Penetrations)	5c	88	9	87
5.	Hotel Chinaware	5c	700	160	77
6.	Files and Rasps	5c	1351	496	65
7.	Rough and Smooth Face Brick	5c	75	2	97
	Common Brick		44	1	98
8.	Range boilers	5c	130	13	90
9.	Woven Wire Fencing	5c	552	69	87
	Woven Wire Fence Packages		2072	138	93
10.	Milk Bottle and Caps—(Bottles)	5c	49	4	92
	(Caps)		10	1	90
11.	Bed Blankets (Sizes)	5c	78	12	85
12.	Hollow Building Tile (1st Rev.)	5c	36	20	44
13.	Structural Slates for Plumbing and Sanitary Purposes	5c	827	138	82
14.	Roofing Slates	5c			
	Descriptive Terms				
	Thicknesses and Sizes		98	48	51
15.	Blackboard Slates	5c			
	Slab Heights and Sizes		251	25	90
16.	Lumber (Second Revision)	15c	Standard Nomenclature Grades and Sizes for Soft-Wood Lumber		
17.	Forged Tools	5c	665	351	47
18.	Builders' Hardware (1st Rev.)	10c (2)			
	(Items)		6948	5130	26
	(Finishes)		100	29	71
19.	Asbestos Paper	5c			
	Sizes, widths, weights of Rolls		72	12	83
	Asbestos Mill Board				
	Sizes, Thickness		21	4	81
20.	Steel Barrels and Drums	5c	66	24	64
21.	Brass Lavatory and Sink Traps	5c	1114	72	94
22.	Papers	5c (1)		15	
23.	Plow Bolts	5c	1500	840	44
24.	Hospital Beds	5c			
	Length		33	1 Standard	97
	Width		34	2 Specials	91
	Height		44	1	98
25.	Hot Water Storage Tanks	5c	120	14	88
26.	Steel Reinforcing Bars	5c			
	Cross-sectional areas		40	11	73

SPR No.	Item		Price Reduction in Varieties From	To	Per Cent Reduction
27.	Cotton Duck (Widths and Weights)	5c	460	90	80
28.	Sheet Steel (First Revision)	5c	1819	263	85
29.	Eaves Trough and Conductor Pipe	5c	21	16	24
30.	Terne Plate (Weights)	5c	9	7	22
31.	Loaded Shells (Second Revision)	5c	4076	1758	57
32.	Concrete Building Units. (Length, Width and Height of Blocks Tile and Brick)	5c	115	24	80
33.	Cafeteria and Lunch Room Chinaware	5c	668	117	73
34.	Warehouse Forms	10c	Thousands	15	
35.	Steel Lockers	5c	65	17	74
36.	Milling Cutters	5c	944	570	40
37.	Commercial Purchase Forms	5c	Thousands	3	
38.	Sand Lime Brick (Length, Width and Height)	5c	14	3	79
39.	Dining Car Chinaware	5c	700	113	84
40.	Hospital Chinaware	5c	700	113	84
41.	Insecticides and Fungicides (Packages)	5c	38	21	45
42.	Paper Grocers' Bags	5c	6280	4700	25
43.	Paint and Varnish Brushes	5c	480	138	71
44.	Box Board Thicknesses	5c	244	60	75
45.	Grinding Wheels	10c	715,200	255,800	64
46.	Tissue Paper (Roll Tissure)	5c	13	3	77
	Shoe Tissue		21	6	72
47.	Cut Tacks and Small Cut Nails, Sizes	5c	428	181	58
	Packing Weights		423	121	71
48.	Shovels, Spades and Scoops	5c	5136	2178	57
49.	Sidewalk Lights (Sizes)	5c	120	6	95
	Styles		80	5	94
	Shapes		10	2	80
50.	Checks, Notes, Etc	5c	Thousands	One Size for Each Instrument	
51.	Die Head Chasers (For Self-Opening and Adjustable Die Heads)	5c			75
52.	Staple Vitreous China Plumbing	5c			
	Fixtures		441	58	87
53.	Steel Reinforcing Spirals	5c	7	3	58
54.	Sterling Silver Flatware	5c	190	62	67
55.	Tinware, Galvanized and Japanned Ware	5c	1154	873	24
56.	Carbon Brushes and Brush Shunts	5c (3)			
57.	Wrought Iron and Wrought Steel Pipe Valves and Pipe Fittings	5c			
	Sizes of Valves and Fittings		20,000	19,238	4
	Sizes of Pipe		62	49	21
58.	Classification of Iron and Steel Scrap	10c	Specification for Scrap		
59.	Rotary Cut Lumber Stock for Wire-bound Boxes	5c			
	Length		102	6	94
	Width		65	6	91
	Thickness		9	6	33
62.	Metallic Cartridges	5c	348	256	26

SIMPLIFIED PRACTICE RECOMMENDATIONS IN PROCESS OF ACCEPTANCE

S.P.R. No.	Item	Reduction in Varieties From	To	Per Cent Reduction
*60.	Packing of Bolts and Nuts	(1)	18	
*61.	White Glazed Tile and Unglazed Ceramic Mosaic	(4)		
*63.	Metal Spools and Reels	(1)	6	
*64.	Spark Plugs	(1)	6**	
*65.	Piston Rings Oversizes	(1)	6**	
*66.	Brake Linings	(1)	37**	
*67.	Taper Roller Bearings	(1)	172**	
*68.	Flashlight Cases	25	14	44
*69.	Razor Blade Packages	(2 systems of packing reduced to 1)		50
*70.	Salt Containers	35	19	46
*71.	Grading of New Billet Steel for Concrete Reinforcement	(3 grades of steel reduced to 1)		67
*72.	Solid Section Steel Sash	42,877	2244	95
*73.	One-Piece Porcelain Insulators	272	249	9
*74.	Hospital and Institutional Textiles	575	26	95
*75.	Composition Blackboard			
	Colors	3	1	66
	Widths	18	8	55
	Lengths	54	13	76
*76.	Ash Handles (Grades)	(1)	3	

(1) Original Total not known.
(2) These figures are the average reduction in catalogue items in 1922 of four leading manufacturers of Builders' Hardware as result of simplification.
(3) Increments of increase in dimensions, and dimensional tolerances for carbon brushes, sizes of holes or slots in terminals for flexible shunts, and size and specifications for cable for brush shunts.
(4) Shapes, patterns, dimensions, grade nomenclature, grade marks, grade specifications and certifications of grades, for white glazed tile and unglazed ceramic mosaic.
** Society of Automotive Engineers Standards.

WORLD INTERNATIONAL STANDARDIZATION

(Supplemental Memorandum with Report of Special Committee on Standardization)

The closely knit business relationship of nations has made it necessary for them from time to time to agree upon unified business arrangements in their public affairs, as in the case of the International Postal Union, a tablet in celebration and record of which has been erected in Berne, Switzerland, and more particularly perhaps in the matter of Weights and Measures.

These large affairs can best be dealt with by the governmental authorities of nations, which leads governments into the field of Standardization. The Seventh International Conference on Weights and Measures was held last September in Paris and the memorandum of the conference stated in the Technical News Bulletin of the Bureau of Standards, November, 1927, is reproduced for the information of our members:

Seventh International Conference on Weights and Measures

A remarkable advance toward complete international agreement on fundamental questions of measurement took place at the Seventh International Conference on Weights and Measures, held last September in Paris.

At this conference the United States was represented by the Director of the Bureau of Standards. The present year is the fiftieth anniversary of the establishment of the International Bureau of Weights and Measures, and in commemoration of the event a special meeting was held under the auspices of the French Academy of Sciences in connection with the conference. A history of the International Bureau by its director, Dr. Ch.-Ed. Guillaume, was published and gives an interesting review of past achievements.

The conference just held was the most important in point of results secured since the first conference in 1875. The actions taken affect fundamentally many kinds of measurements and standards and are based on the results of painstaking scientific research, covering many years. The new decisions involve the international temperature scale, the fundamental standard of length of the world, and the basis of the world's electrical units.

Under the treaty of May 20, 1875, there was established the International Committee on Weights and Measures, the International Bureau of Weights and Measures, and the International Conference on Weights and Measures. The treaty, to which 31 of the leading governments are now parties, gives the conference jurisdiction over the fundamental problems affecting the international metric standards and precise metrology. The royal grounds and residence at Sèvres set aside by the French Government were made internationally neutral territory to be devoted to the International Bureau of Weights and Measures, where the international standards were to be deposited and the precise comparisons of national standards executed from time to time. Here were made the final standards of the meter and kilogram, and here these standards were intercompared for distribution to the various governments of the world. This historic center is now replete with records of achievements in the science and art of measurement during the past half century.

The international conference meets once in six years and is made up of delegates from the 31 national governments. Adoption of any proposition by the conference can only be secured by the unanimous vote of all nations represented, each nation having one vote. The recommendations of the conference are (in effect and when ratified) binding on the signatory powers, and because of this fact and because unanimous agreement is required for adoption the process of effecting important changes is usually slow.

Immediately before the conference just held the Director of the Bureau of Standards met with the representatives of the national laboratories of Great Britain and Germany, and in an informal conference these three nations agreed on every value for the international temperature scale. These values were accepted by the international conference, with the understanding that a special international committee would be chosen to study the matter of temperature measurements and recommend such revisions as may be found necessary from time to time in the future.

The significance of the final adoption of the international temperature scale by 31 nations is a matter of such great interest to science and industry that a brief summary of what this involves should be given. The action assures the following desirable ends:

1. A uniform basis for expressing all quantities involving temperature and heat measurement, such as tables of properties of refrigerants, steam tables, heats of combustion, specific and latent heat of materials, and particularly fixed temperatures, such as freezing, boiling, and transition temperatures of substances.

2. A uniform basis for calibration of all temperature-measuring instruments, particularly those for export from one nation to another. This is particularly important in the case of pyrometers for use at very high temperatures.

3. A common basis in all countries for the certification of precision temperature-measuring instruments for use in all precise experimental or research work involving temperature measurements. Such basis is now so

well defined and universally understood as to make it unnecessary for the researcher in publishing his results either to establish or define his own temperature scale as has often been necessary in the past.

4. While for a number of years the three national laboratories of England, Germany, and the United States have been in substantial agreement in the certification of temperature-measuring instruments, the adoption of their recommendations by the international bureau will have the effect of bringing all the important countries of the world together in the matter of temperature measurements, and will stabilize the basis of temperature measurement and eliminate differences in details. The desire to eliminate such differences has already led the laboratories to make intercomparisons of calibrated instruments in preparation for the formal adoption of the scale, and this interchange will lead to the establishment of closer and more cordial relations.

5. It is also significant that each of the laboratories has been willing to modify its position where necessary, since it was apparent to all that international agreement was of much greater importance than precise adherence to the practice of the individual laboratories.

The proposition of the United States to define the length of the international meter in terms of the wave length of the red radiation from the cadmium lamp was also tentatively adopted, the final wording of the recommendation as decided upon by the conference being an improvement on that submitted by the United States. As a result of this action, there is now established a permanent natural standard of length, easily reproduced, and capable of being used in the most precise measurements we are ever called upon to make. Although the particular line chosen in the spectrum of cadmium is believed to be a very good one for this purpose, the way has been left open to utilize a better line, such as one of those in the spectrum of Krypton, if future investigations prove this to be desirable.

The conference tentatively adopted the value determined by Fabry and Perot in 1906 as expressing the relation between the international meter and the wave length of red light from cadmium vapor. This relation is

$$1 \text{ meter} = 1{,}553{,}164.13 \text{ waves}$$

under certain definitely stated standard conditions.

The wave length of cadmium light is thus accepted as a standard in terms of which lengths may be measured and other light wave standards may be expressed. This action is of great importance because of the fact that many precise length measurements in science and industry are now made in terms of light waves, and is particularly useful for setting up and intercomparison of gage blocks and other subdivisions of the meter.

It was also the hope of the United States delegates that the conference would adopt or recommend a definite relation between the yard and the wave length of light, or between the yard and the meter. The adoption of such a relation is equally important, since it would overcome a difficulty which often arises; that is, of converting wave lengths to inches, a different relation being used in this country and in Great Britain.

This agreement on the length of the British and American yards, which now differ by a few millionths of an inch, unfortunately was not brought about. Research is now in progress in England on the length of their national standard, and pending the completion of this work it appeared impossible to reach an understanding. The difference is very small, but is becoming of importance in making some of the finer measuring tools now used by industry. It was held by the conference, however, that the relation between the yard and the meter, or between the yard and the wave length of light, was a matter that should be settled by the United States and Great Britain rather than by the international conference, and no action was therefore taken. However, the British delegates expressed themselves as heartily in favor of the idea, and agreement between the systems of the two countries will undoubtedly be brought about in time.

The matter of standard temperatures at which end standards (gage blocks) shall be certified was also considered in connection with length measurements. It is desirable to employ a temperature or temperatures at which the blocks are actually used. At present, there are many variations in the practice of different nations. A committee will be chosen to consider the question and, if possible, agree upon not more than two standard temperatures at which end standards will be certified.

The third major problem considered by the conference was the standardization of the electrical units and the scope of the international bureau in relation to electrical measurements.

Up to the present time international agreements with regard to electrical measurements have been made by electrical congresses and international committees formed for this specific purpose. The number of international organizations has, however, multiplied so greatly that it has become desirable to combine them and reduce the number of special organizations. In accordance with this general principle the international conference has been authorized to establish electrical units.

The United States is concerned with maintenance of international uniformity in electrical measurements for two practical reasons. One is the need for uniformity in manufacture and rating of electrical machinery and appliances, and the other the international use of the results of scientific research. In order to bring about such uniformity, agreement was reached many years ago on certain electrical units which were called "international" to distinguish them from the "absolute" values which might be found more or less different from the accepted units as methods of measurement were perfected. In fact, such a difference has been found in the case of the ohm, and we now know that the international ohm is one-twentieth of 1 per cent too large. While such a difference is of no great practical importance at the present time, the demands of industry for precise measurements are growing rapidly, and such a difference may become important in the future. The international committee must, therefore, decide whether to maintain the old value of the ohm or to adjust it to accord with mechanical measurements as originally intended

When the international units were adopted certain kinds of concrete standards were also accepted as a means of maintaining the values of the unit. These are a column of mercury of specified dimensions for the ohm, and a voltmeter in which the amount of silver deposited in a given time by a current is used as a measure of the ampere. The international committee must decide whether to retain these old standards or to substitute new methods of establishing the units which have been developed in the several national laboratories.

In order to advise it as to the best solution for these questions, the international committee is establishing a special technical commission of 10 members, including representatives appointed by the several national laboratories, and is to report by March, 1929.

For several years the Bureau of Standards has been putting as much attention as it could on these fundamental electrical problems and has already made some redeterminations of the true value of the ohm and the ampere by absolute methods. In order to be of value the results of such work must be certain to be within a few parts in 100,000, and, therefore, many precautions must be taken which are entirely unnecessary in any ordinary measurements. The work is therefore very time consuming, and still more intensive effort must be put upon it in order to have results available by the spring of 1929.

REPORT OF COMMITTEE XX—UNIFORM GENERAL CONTRACT FORMS

J. C. Irwin, *Chairman;*
C. Frank Allen,
H. E. Barlow,
W. H. Brameld,
B. S. Dickerson,
W. D. Faucette,
F. H. Fechtig,
B. Herman,
J. S. Lillie,
S. L. Mapes,
A. A. Miller,
O. K. Morgan,
Clark Dillenbeck, *Vice-Chairman;*
Samuel Murray,
F. L. Nicholson,
C. B. Niehaus,
W. G. Nusz,
H. A. Palmer,
Chas. Silliman,
Huntington Smith,
E. L. Taylor,
C. A. Wilson,
John Worley,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).
(2) Form of Agreement for Joint Use of Freight Terminal Facilities (Appendix B).
(3) Form of Agreement for Use of Railway Property for Public Highways (Appendix B).
(4) Form of Construction Contract for Particular Items of Work (Appendix C).
(5) Form of Cost-Plus Percentage Construction Contract (Appendix C).
(6) Form of Agreement for Joint Ownership, Use and Management of a Terminal Project (Appendix B).

Action Recommended

1. That the changes in the Manual in Appendix A be approved and the revised version substituted for the present recommendation in the Manual.

2. That the Form of Agreement for Joint Use of Freight Terminal Facilities, as printed in Appendix B, be approved for publication in the Manual.

3. That the subject "Form of Agreement for Use of Railway Property for Public Highways" be eliminated from the Outline of Work, as there seems to be no general need for such standard form.

4. That the conclusions in Appendix C in regard to the method of preparing a Form of Construction Contract for Particular Items of Work, be followed and that this subject be eliminated from the Outline of Work.

5. That the Form of Cost-Plus Percentage Construction Contract, as printed in Appendix C, be received as information and for discussion.

6. That the subject "Form of Agreement for Joint Ownership, Use and Management of a Terminal Project" be included in the Outline of Work for the ensuing year.

Recommendations for Future Work

1. Revision of Manual.
2. Form of Agreement for Joint Ownership, Use and Management of a Terminal Project.
3. Continue study of Form of Cost-Plus Percentage Construction Contract.
4. Form of Agreement for Purchase of Electrical Energy in Large Volume (such as required for Traction Purposes).
5. Form of Application for Industry Track.
6. Outline of Work for ensuing year.

Respectfully submitted,
THE COMMITTEE ON UNIFORM GENERAL CONTRACT FORMS,
J. C. IRWIN, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

F. L. Nicholson, Chairman, Sub-Committee; C. Frank Allen, Clark Dillenbeck, W. D. Faucette, O. K. Morgan, Samuel Murray, H. A. Palmer, Chas. Silliman, C. A. Wilson.

FORM OF AGREEMENT FOR INTERLOCKING PLANT
FORM OF AGREEMENT FOR INDUSTRY TRACK

Your Sub-Committee has given careful consideration to these subjects and recommends that the forms as revised be approved and substituted for the forms now printed in the Manual.

The recommendations for changes in the Form of Agreement for Interlocking Plant result from joint study of the form by this Sub-Committee and Committee VII of the Signal Section, American Railway Association.

The recommendations for changes in the Form of Agreement for Industry Track result from conferences of a Special Committee of Committee XX headed by the General Chairman, with representatives of the Industries and with Consulting Counsel, and especially from joint meetings between members of Committee XX and representatives of the American Petroleum Institute. Study of the Liability Section is still in progress and this is not included in present recommendations, but your Sub-Committee hopes to make definite report on this subject at the annual meeting.

FORM OF AGREEMENT FOR INTERLOCKING PLANT

Adopted 1918, Vol. 19, pages 358 and 1177

Present	*Proposed*
THIS AGREEMENT, made this .... day of ..... 19... by and between ..... hereinafter called the ..... Company and..... hereinafter called the ..... Company	THIS AGREEMENT, made this .... day of ..... 19... by and between ..... hereinafter called the ..... Company and..... hereinafter called the ..... Company .....

Present

WITNESSETH THAT:

WHEREAS,

(Note.—Include brief description of conditions, including the location of existing or proposed grade crossing; an enumeration of all existing agreements, if any; the names of the companies between which agreements were made, their dates, purpose, etc.)

WHEREAS, the parties hereto mutually desire to construct, maintain, renew and operate an interlocking plant at said crossing; the location of said crossing being shown, and the said interlocking plant to be arranged as shown on the blue print marked Exhibit A, dated ..... identified by the signatures of the ..... of the ..... Company, and of the ..... of the ..... Company, hereto attached, and hereby made a part of this agreement.

NOW, THEREFORE, in consideration of the premises and of the mutual conditions and agreements hereinafter set forth, the parties hereto do covenant and agree as follows:

Definition

1. No change.

Construction

2. The ..... Company agrees to construct an interlocking plant, as shown on said Exhibit A, and in accordance with specifications which have been approved by the ..... of the parties hereto, and identified by their signatures.

The cost of removing any existing safety appliances or devices shall be divided in like manner as the maintenance and renewal expense of said appliances or devices has heretofore been divided.

The ..... Company agrees to begin the construction of said interlocking plant within .... days after the execution of this agreement, and to carry the same forward to a prompt completion.

(Note.—Insert penalty clause if desired)

Proposed

WITNESSETH THAT:

WHEREAS,

(Note.—Include brief description of conditions, including the location of existing or proposed grade crossing; an enumeration of all existing agreements, if any; the names of the companies between which agreements were made, their dates, purpose, etc.)

WHEREAS, the parties hereto mutually desire to construct, maintain, renew and operate an interlocking plant at said crossing, the location of said crossing and the arrangement of the interlocking plant to be as shown on the blue print marked Exhibit A, dated ..... identified by the signatures of the ..... of the ..... Company, and of the ..... of the ..... Company, hereto attached, and hereby made a part of this agreement.

NOW, THEREFORE, in consideration of the premises and of the mutual conditions and agreements hereinafter set forth, the parties hereto do covenant and agree as follows:

Definition

1. The term Interlocking Plant, herein contained, shall be held and taken to include any and all houses, towers, power plants, machinery, appliances and appurtenances required for the operation of the same.

Construction

2. The ..... Company agrees to construct an interlocking plant, as shown on said Exhibit A, and in accordance with specifications which have been approved by the ..... of the parties hereto, and identified by their signatures.

The ..... Company agrees to begin the construction of said interlocking plant within..... days after the execution of this agreement, and to carry the same forward to a prompt completion.

Present

Apportionment of Cost

3. (a) The cost of constructing, maintaining and renewing said interlocking plant, as shown on said Exhibit A, shall be borne by the parties hereto as follows:

Each party hereto shall participate in the ownership of said interlocking plant in the ratio which the payments made by it for construction of said interlocking plant, including extensions and changes chargeable to capital account, bear to the total cost of construction thereof.

(c) The expense of maintaining and renewing said interlocking plant shall include taxes, assessments and insurance; all losses by fire, flood or other damage caused by the elements; also any change made necessary by an act, law or ordinance, of a lawfully constituted public authority.

(d) The cost of operating said interlocking plant, including power, heat, light, and supplies, shall be borne by the parties hereto as follows:

Proposed

Apportionment of Cost

3. (a) The cost of removing any existing safety appliances or devices shall be divided in like manner as the maintenance and renewal expense of said appliances or devices has heretofore been divided.

(b) The cost of constructing, maintaining and renewing said interlocking plant, as shown on said Exhibit A, shall be borne by the parties hereto as follows:

Each party hereto shall participate in the ownership of said interlocking plant in the ratio which the payments made by it for construction of said interlocking plant, including extensions and changes chargeable to capital account, bear to the total cost of construction thereof.

(c) The cost of maintaining and renewing said interlocking plant shall include taxes, assessments and insurance; all losses by fire, flood or other damage caused by the elements, strikes or other such contingencies, also any expense made necessary by an act, law or ordinance, of a lawfully constituted public authority.

(d) The cost of operating said interlocking plant, including the wages of the operators and signal men together with the cost of power, heat, light, and supplies, shall be borne by the parties hereto as follows:

..... Company .....
.....
..... Company .....
.....

any other expenses properly chargeable to operations, shall be borne by the parties hereto in the same proportion as provided for maintenance in paragraph 3 (b).

Present

Spare Space

(Omitted in Proposed Form)

4. Spare levers, machine spaces, and building space, may be provided for its exclusive use upon request of either of the parties hereto, at the sole cost and expense of such party; provided further, that the other party to this agreement may hereafter acquire the right to the exclusive use of the same by either paying the original cost, or by providing an equal amount of space of the kind used when the same shall be required, at the election of the party which originally provided the spare space.

Extensions and Changes

5 (Renumbered 4). Either party shall have the right to make extensions or changes in said interlocking plant, provided that they shall not materially impair the efficiency of the same. All such extensions or changes, arising from changes made in any existing track or tracks, or made to cover any future track or tracks or connections, which either party hereto may have the right to construct, or which may be required by reason of any changes made in the standard appliances of either party, or which may be ordered by a lawfully constituted public authority, shall be made by the ..... Company, and the cost of such extensions or changes shall be borne by the party hereto for whose benefit said extensions or changes are made, and the amount chargeable to each party for maintenance, renewal and operation in such case shall be determined as follows:

Control of Plant

6 (Renumbered 5). MAINTENANCE (a) and (b). No change.

Proposed

Extensions and Changes

4. Either party shall have the right to make extensions or changes in said interlocking plant, provided that they shall not materially impair the efficiency of the same. All such extensions or changes, arising from changes made in any existing track or tracks, or made to cover any future track or tracks or connections, which either party hereto may have the right to construct, or which may be required by reason of any changes made in the standard appliances or practices of either party, or which may be ordered by a lawfully constituted public authority, shall be made by the .... Company, and the cost of such extensions or changes shall be borne by the party hereto for whose benefit said extensions or changes are made, and the proportion chargeable to each party for maintenance, renewal and operation in such case shall be determined as follows:

Control of Plant

5. MAINTENANCE. (a) The maintenance and renewal of said interlocking plant shall be under the sole charge and control of the .... Company, and it shall employ competent persons to maintain and renew the same, and such parties

Present	*Proposed*
	from time to time so employed shall be removed for good and sufficient reason upon request in writing of a general managing officer of the ..... Company. Each of the parties hereto, through its authorized employees and representatives, shall have the right at all times to inspect said interlocking plant, as well as the accounts covering the construction, maintenance, renewal and operation of the same; and in the event that the .... Company shall notify the ..... Company, in writing, of renewals and repairs that may be necessary for the safe and proper operation of said interlocking plant, and if the .... Company neglects for a period of thirty days to make said necessary renewals and repairs, then the ..... Company shall have the right to make such renewals and repairs, and the .... Company shall, upon presentation of proper bills, and within the time provided in Section 8 hereof, pay its proportion of the amount so expended. (b) Each of the parties hereto shall, at its own expense, keep all switches and derails in its own tracks free from ice, snow, dirt or other obstructions which may interfere in any way with the proper working of said interlocking plant: and in case either party fails to do so, the other party may enter upon the premises of the party at fault and remove such ice, snow, dirt or other obstructions; in which event, the party at fault shall reimburse the party doing such work, as provided in Section 8 hereof, for all expense thereby incurred.
Operation. (c) The operation of said interlocking plant shall be under the sole charge and control of the ..... Company, and it shall employ competent persons to operate the same, and such persons from time to time so employed shall be removed for good and sufficient reasons upon request in writing of a general managing officer of the ..... Company.	Operation. (c) The operation of said interlocking plant shall be under the sole charge and control of the ..... Company, and it shall employ competent persons to operate the same, and such persons from time to time so employed shall be removed for good and sufficient reasons upon request in writing of a general managing officer of the ..... Company.

Present

It is further mutually understood that either party may use the operators at said interlocking plant in its telegraph or telephone service, provided said party shall give the other party at least ten days' prior written notice of the same; but in the event that additional expense is so incurred, either on account of increased wages of operators over levermen, or on account of additional employees required, the party using the operators in its service shall bear the additional expense. If for any reason it becomes necessary to temporarily take the said interlocking plant out of service, the control of the flagmen required to protect said grade crossing shall also be in the ..... Company, and the expense of said flagmen shall be considered, for the purpose of apportionment, as an expense of operating said interlocking plant.

Material and Labor Supplied by Parties

7 (Renumbered 6). Each of the parties hereto shall, without cost to the other, furnish and install its own derails, switch points, switch rods, special switch and derail ties and timbers, all track insulations, poles, cross-arms, pins and insulators, and will maintain and renew them from time to time thereafter; likewise, without cost to the other party, do all the track work and grading along its own tracks necessary to prepare the same for the installation of said interlocking plant, and also provide and maintain proper drainage; likewise, bear the cost and expense of raising and adjusting pipe carrier and mechanism foundations, or the renewal of detector bars, clips or any other appliances required or made necessary by the resurfacing, reballasting or rail renewal of its tracks within the limits of said interlocking plant; likewise, furnish and install at its own expense any signal bridges, or other

Proposed

It is further mutually understood that either party may use the operators at said interlocking plant in its telegraph or telephone service, provided said party shall give the other party at least ten days' prior written notice of the same; but in the event that additional expense is so incurred, either on account of increased wages of operators over levermen, or on account of additional employees required, the party using the operators in its service shall bear the additional expense. Should both parties hereto require additional service, the cost shall be borne by each party in proportion to service rendered. If for any reason it becomes necessary to temporarily take the said interlocking plant out of service, the control of the flagmen required to protect said grade crossing shall also be in the .... Company, and the expense of said flagmen shall be considered, for the purpose of apportionment, as an expense of operating said interlocking plant.

Material and Labor Supplied by Parties

6. Each of the parties hereto shall, without cost to the other, furnish and install its own derails, switch points, switch rods, special switch and derail ties and timbers, all track insulations, poles, cross-arms, pins and insulators, and will maintain and renew them from time to time thereafter; likewise, without cost to the other party, do all the track work and grading along its own tracks necessary to prepare the same for the installation of said interlocking plant, and also provide and maintain proper drainage; likewise, bear the cost and expense of raising and adjusting pipe carrier and mechanism foundations, or the renewal of detector bars, clips or any other appliance required or made necessary by the resurfacing, reballasting or rail renewal of its tracks within the limits of said interlocking plant; likewise, furnish and install at its own expense any signal bridges, or other special signal supports, which

Present

special signal supports, which may be required to support signals governing the movement of trains on its tracks.

Either party shall have the right to carry its automatic block signaling through the limits of the interlocking plant at its own expense. Where signals perform the function of both block and interlocking signals, the party hereto whose train movements are controlled by said block signals shall maintain the same at its expense.

Precedence

8 (Renumbered 7). No change.

Payment of Bills

9 (Renumbered 8). No change.

Proposed

may be required to support signals governing the movement of trains on its tracks.

Either party shall have the right to carry its automatic block signaling through the limits of the interlocking plant at its own expense. Where signals perform the function of both block and interlocking signals, the party hereto whose train movements are controlled by said block signals shall maintain the same at its expense, provided, however, that work within home signal limits shall be done by plant maintaining party, or under its supervision, at expense of owning company.

Precedence

7. In the use of said interlocking plant, passenger, mail and express trains shall have precedence over freight trains and light engines; and freight trains shall have precedence over light engines. The trains and engines of the ..... Company shall have precedence over the trains and engines of like class of the .....Company.

Payment of Bills

8. All payments hereunder shall be made within thirty days after rendition of proper bills.

The ..... Company shall render bills covering the cost of constructing said interlocking plant, such expense to be billed in one statement unless otherwise agreed upon by the parties hereto.

Bills covering the operation, maintenance and renewal of said interlocking plant shall be rendered monthly; and those covering insurance, taxes and assessments, annually.

Such of said bills as are based upon payroll cost of labor and stock prices or material shall include a fair arbitrary charge to cover supervision, inspection, handling, transportation, accounting and similar undistributed items of expense. Such fair arbitrary charge shall be in accordance with the recommendations of the General Managers' Association of.....

Present

Proposed

....., in effect from time to time, or in the absence of any such recommendations, shall be agreed to by the parties, or determined by arbitration as hereinafter provided.

Should dispute arise as to the correctness of any items included in bills rendered under this agreement, the party against which such bills are rendered shall pay all items concerning which there is no dispute, and the other items shall be paid promptly when the correctness thereof has been ascertained by arbitration or otherwise.

Liability

10 (Renumbered 9). Each party hereto assumes for itself the responsibility and risk of using and operating its own trains and engines over the space covered by the said interlocking system, and also responsibility for the negligent acts and omissions or the alleged negligent acts or omissions of its own officers, agents, servants and employees engaged in connection therewith; and in performance of any of its separate duties under this contract; and will pay to the other party and to third persons all damages which may arise and for which it may be liable, arising from such negligence and in such operation.

The party having special charge of the management and operation of said interlocking system shall not be liable to the other party for the negligent acts or omissions, or the alleged negligent acts or omissions, of any person employed in the operation, maintenance or repair of said interlocking mechanism, but all persons so employed shall, as respects any injury caused by such negligence, be regarded and treated as the agents or servants of each party hereto, and each of said parties hereby assumes the responsibility for all damages resulting from the negligence of such agents or servants in the operation of its own engines, cars and trains, and those

Liability

9. Each party hereto assumes for itself the responsibility and risk of using and operating its own trains and engines over the space covered by the said interlocking plant, and also responsibility for the negligent acts and omissions of its own officers, agents, servants and employees engaged in connection therewith; and in performance of any of its separate duties under this contract; and will pay to the other party and to third persons all damages which may arise and for which it may be liable, arising from such negligence and in such operation.

The party having special charge of the management and operation of said interlocking plant shall not be liable to the other party for the negligent acts or omissions of any person employed in the construction, maintenance, operation or renewal of said interlocking plant, but all persons so employed shall, as respects any injury caused by such negligence, be regarded and treated as the agents or servants of each party hereto, and each of said parties hereby assumes the responsibility for all damages resulting from the negligence of such agents or servants in the operation of its own engines, cars and trains, and those of its tenants, lessees and licensees, at the said crossings, and shall in-

Present

of its tenants, lessees and licensees, at the said crossings, and shall indemnify and save the other party harmless therefrom. Any expense caused or growing out of the injury of any workman or employee engaged upon the construction of said interlocking plant shall be held and considered to be a construction expense, and shall be divided as herein in Section 3 provided.

Arbitration

11 (Renumbered 10). In case of any differences or dispute arising under this agreement or concerning the subject-matter thereof, the parties hereto agree to submit such differences or dispute to three arbitrators, one of whom shall be appointed by the..... Company, and another by the..... ..... Company, and each party shall give to the other party written notice of appointment of its arbitrator, together with his name and address. The two arbitrators so chosen shall select a third arbitrator. If either party shall fail to choose an arbitrator as herein provided, the arbitrator selected by the other party hereto, at the expiration of ..... days after the date of its said written notice, shall select a second arbitrator, and the two arbitrators so chosen shall select a third arbitrator. If within ..... days after the appointment of a second arbitrator, as herein provided, the two so chosen shall have failed to select a third arbitrator, either party hereto may apply to any judge of the District Court of the United States for the District which shall then include ..... or ..... who shall thereupon appoint the third arbitrator. The three arbitrators so chosen in any manner as herein provided, or a majority of them, shall hear and decide said difference or dispute, and their decision, or that of a majority of them, shall be final and binding on the parties hereto.

The expense of an arbitration under the terms hereof shall be borne by the parties hereto in the proportions fixed by the arbitrators.

Proposed

demnify and save the other party harmless therefrom. Any expense caused or growing out of the injury of any workman or employee engaged upon the construction of said interlocking plant shall be held and considered to be a construction expense and shall be divided as herein in Section 3 provided.

Arbitration

10. In case of any differences or dispute arising under this agreement or concerning the subject-matter thereof, the parties hereto may agree to submit such differences or dispute to three arbitrators, one of whom shall be appointed by the ..... Company, and another by the ..... Company, and each party shall give to the other party written notice of appointment of its arbitrator, together with his name and address. The two arbitrators so chosen shall select a third arbitrator. If either party shall fail to choose an arbitrator as herein provided, the arbitrator selected by the other party hereto, at the expiration of..... days after the date of its said written notice, shall select a second arbitrator, and the two arbitrators so chosen shall select a third arbitrator. If within ..... days after the appointment of a second arbitrator, as herein provided, the two so chosen shall have failed to select a third arbitrator, either party hereto may apply to any judge of the District Court of the United States for the District which shall then include ..... or ..... who shall thereupon appoint the third arbitrator. The three arbitrators so chosen in any manner as herein provided, or a majority of them, shall hear and decide said difference or dispute, and their decision, or that of a majority of them, shall be final and binding on the parties hereto.

The expense of an arbitration under the terms hereof shall be borne by the parties hereto in the proportions fixed by the arbitrators.

Present

Cancellation of Conflicting Agreements

12 (Renumbered 11). No change.

Duration and Succession

13 (Renumbered 12). No change.

Proposed

Cancellation of Conflicting Agreements

11. It is mutually understood and agreed that any and all agreements existing between the parties hereto or their predecessors, so far as they conflict, or are inconsistent with the terms and conditions of this agreement, are hereby annulled, but in all other respects they shall continue in full force and effect.

Duration and Succession

12. This agreement shall take effect on the ..... day of ..... 19...., and shall continue in force during the existence and operation of the interlocking plant, or until discontinued by the mutual agreement of the parties hereto.

The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

In Witness Whereof, the parties hereto have caused this agreement to be executed, in duplicate, by their respective officers, thereunto duly authorized, the day and year first above written.

.. ..
Secretary.

..... Company,

By .....

.. ..
Secretary.

..... Company,

By .....

FORM OF INDUSTRY TRACK AGREEMENT

As Adopted 1923—Vol. 24 (Pages 515, 1185 and 1188)

FORM OF AGREEMENT FOR INDUSTRY TRACK

Present

THIS AGREEMENT, made this .... day of ..... 19..., between ..... hereinafter called the Railway Company, and ..... hereinafter called the Industry;

WITNESSETH,

WHEREAS, the Industry desires track facilities, hereinafter called sidetrack, for the economical and convenient conduct of the business of the Industry, at or near .... Station, County of ....., State of ....., described as follows:

in accordance with plan numbered ..... dated ..... designated as ....hereto attached and made a part hereof; and

WHEREAS, the operation of cars and engines over said sidetrack at other than the regularly established station facilities of the Railway Company, involves the risk of damage to or destruction of property and injury to or death of persons;

NOW, THEREFORE, in consideration of the covenants and agreements herein contained, it is mutually agreed that the said sidetrack shall be constructed and maintained, and the Railway Company hereby agrees to operate the same under the following terms and conditions:

Right-of-Way

1. No change.

Proposed

THIS AGREEMENT, made this .... day of ..... 19..., between ..... hereinafter called the Railway Company, and ..... hereinafter called the Industry;

WITNESSETH,

WHEREAS, the Industry desires track facilities, hereinafter called sidetrack, for the economical and convenient conduct of the business of the Industry, at or near .... Station, County of ....., State of ....., described as follows:

in accordance with plan numbered ..... dated ..... designated as ....hereto attached and made a part hereof:

NOW, THEREFORE, in consideration of the covenants and agreements herein contained, it is mutually agreed that the said sidetrack shall be constructed and maintained, and the Railway Company hereby agrees to operate the same under the following terms and conditions:

Right-of-Way

1. The Industry shall provide, without cost to the Railway Company, all necessary right-of-way outside of the right-of-way of the Railway Company, required for the proper construction and operation of said sidetrack, said right-of-way to be satisfactory to the..... ..... of the Railway Company.

Present	*Proposed*
	The cost and expense of procuring or complying with any ordinance, order, permit or consent whatsoever required by municipal, State, or other lawfully constituted authorities for the construction, maintenance, operation and use of said sidetrack shall be borne by the Industry. The Railway Company shall have the right to enter upon the property of the Industry, for the purpose of constructing, maintaining and operating said sidetrack.
Construction 2. No change.	**Construction** 2. The cost of constructing said sidetrack, including roadbed, trestles, bridges and all other appurtenances in connection therewith, shall be borne as follows:
Maintenance 3. No change.	**Maintenance** 3. Said sidetrack shall be maintained (including removal of ice and snow) and renewed to the satisfaction of the ..... of the Railway Company; the work shall be performed and the cost thereof borne as follows:
Ownership 4. No change.	**Ownership** 4. The title and ownership of said sidetrack shall be vested as follows:
Use 5. The Railway Company shall have the right to use, without cost, the whole or any part of said sidetrack for general railway purposes, provided such use shall not unreasonably interfere with the use thereof by the Industry. The Industry shall not permit or authorize the use of said sidetrack by or for the benefit of any other person, firm or corporation not one of the parties hereto, nor assign this contract or any rights thereunder, without the written consent of the Railway Company.	**Use** 5. The Railway Company shall have the right to use the whole or any part of said sidetrack, provided such use shall not unreasonably interfere with the use thereof by the Industry. Neither party hereto shall permit or authorize the use of said sidetrack by or for the benefit of any other person, firm or corporation not one of the parties hereto, or assign this contract or any rights thereunder, without the written consent of the other party.

Present

Changes or Enlargement

6. If any change, rearrangement, extension or enlargement of said sidetrack or its structures shall at any time be required by reason of any change in the Railway Company's track or tracks or because of any changes in the operating practice of the Railway or for any other cause, the Railway Company shall not be required to bear any expense resulting therefrom.

Clearances

7. No change

Liability

8. The Industry agrees to indemnify the Railway Company and save it harmless from any and all claims and expenses that may arise or be made for death, injury, loss or damage, resulting to the employees or property of the Railway Company or to the employes or property of the Industry or to any other persons or property upon the premises of the Industry by request or consent of the Industry, whether by fire or otherwise (except where it can be shown that such death or injury to persons was due solely to negligence on the part of employees of the Railway Company), arising out of the construction, maintenance, use or operation of said sidetrack for account of said Industry.

Discontinuance

9. Any and all loss or damage sustained in consequence of any temporary or permanent elimination of said sidetrack, shall be assumed by the Industry, or in event the disposition of the property of the Railway Company, or its future use or development shall make it imprac-

Proposed

Changes or Enlargement

6. If any change, rearrangement, extension or enlargement of said sidetrack or its structures shall at any time be necessary by reason of any change in the Railway Company's track or tracks, or because of any changes in the operating practice of the Railway, the Railway Company shall not be required to bear any expense resulting therefrom.

Clearances

7. The Industry agrees not to permit any obstruction over said sidetrack, less than ..... feet above top of rail, or alongside of said sidetrack less than ..... feet from center of track, with the necessary additional clearance on curves.

Liability

8.
Under study for possible revision.

Discontinuance

9. Any and all loss or damage sustained by the Industry in consequence of any temporary or permanent elimination of said sidetrack, shall be assumed by the Industry, or in event the disposition of the property of the Railway Company, or its future use or development shall make

Present

ticable in the judgment of the.... ..... of the Railway Company to continue the connection, the Industry hereby waives any and all claims therefor.

Cancellation, Termination and Removal

10. No change.

Witness for Railway Company:

.....

.....

Railway Company

By .....

Witness for Industry:

.....

.....

Industry

Proposed

it impracticable in the judgment of the ..... of the Railway Company to continue the connection, the Industry hereby waives any and all claims therefor.

Cancellation, Termination and Removal

10. This agreement shall be terminable upon ..... (.....) days' written notice from either party to the other.

Upon termination of this agreement the Railway Company shall have the right to enter upon the property of the Industry and remove any or all of the material owned by the Railway Company, and shall not be liable to account in any way to anyone for any monies paid or expended on account of any of the track or tracks covered by this agreement, nor for any damages resulting from the removal of any or all of the material owned by the Railway Company.

Until terminated as hereinbefore provided, this agreement shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors and assigns.

In Witness Whereof, the parties hereto have executed this agreement in ..... the day and year first above written.

Witness: (For Railway Company)

.....

(Railway Company)

By .....

.....

Witness: (For Industry)

.....

.....

(Industry)

By .....

Appendix B

(2) FORM OF AGREEMENT FOR JOINT USE OF FREIGHT TERMINAL FACILITIES

(3) FORM OF AGREEMENT FOR USE OF RAILWAY PROPERTY FOR PUBLIC HIGHWAYS

(6) FORM OF AGREEMENT FOR JOINT OWNERSHIP, USE AND MANAGEMENT OF A TERMINAL PROJECT ON THE BASIS OF OUTLINE AS PREPARED BY COMMITTEE XIV—YARDS AND TERMINALS, BULLETIN 294, PAGE 582.

E. L. Taylor, Chairman, Sub-Committee; W. H. Brameld, W. D. Faucette, F. H. Fechtig, B. Herman, J. S. Lillie, S. L. Mapes, A. A. Miller, C. B. Niehaus, W. G. Nusz.

(2) The Committee recommend for adoption the Form of Agreement for Joint Use of Freight Terminal Facilities as printed in Bulletin 293, page 455 with the following modifications:

Page 458 under General Supervision, par. (a) insert the words "including land" after the words "Interchange Tracks."

Page 458 under Use of Freight Station, par. (a) insert the words "including land" after the words "Freight Station."

Page 459 under Use of Transfer Platform, par. (a) insert the words "including land" after the words "Transfer Platform."

Page 459 under Use of Team Track Yard, par. (a) insert the words "including land" after the words "Team Track Yard."

Page 460 under Use of Icing Station, par. (a) insert the words "including land" after the words "Icing Station."

The revised form recommended for adoption is as follows:

FORM OF AGREEMENT FOR JOINT USE OF FREIGHT TERMINAL FACILITIES

THIS AGREEMENT, made this ..... day of ..... 19...., by and between ....., a corporation organized and existing under the laws of the ..... of ..... hereinafter called the ..."A"...Company; and ....., a corporation organized and existing under the laws of the ..... of ..... hereinafter called the..."B"...Company.

WITNESSETH:

That, in consideration of the covenants and agreements herein contained, it is mutually agreed as follows:

Permit and Description

1. The..."A"...Company hereby permits the..."B"...Company to use, during the life of this agreement, jointly with..."A"...Company and

any other railway company or companies, now using or which the..."A"... Company may hereafter permit to use, the Freight Terminal and appurtenant facilities of the..."A"...Company at.....in the.....of..... and.....of.....described as follows:

(a) The Interchange Tracks designated by the..."A"...Company for delivering and receiving cars handled or to be handled for the..."B"... Company at said Freight Terminal and also cars interchanged between the parties.

(b) The Freight Station comprising freight houses, freight offices, platforms, cover sheds, driveways and house tracks.

(c) The Transfer Platform comprising platforms, cover sheds, office and cranes and appurtenant tracks.

(d) The Team Track Yard comprising yard office, tracks and driveways.

(e) The Icing Station comprising icing plant and appurtenant tracks.

All being substantially as shown on plan.....numbered..... dated.....designated as.....
.....
signed by the.....of the respective companies (hereto attached and made a part hereof).

Scope

2. The permission of joint use hereunder contemplated is confined to the use by the..."B"...Company of the said Freight Terminal and appurtenant facilities of the..."A"...Company for the sole purpose of conducting the freight business of the..."B"...Company.

Service

3. The..."A"...Company shall furnish and control all employees and appliances necessary in the judgment of the..."A"...Company for the operation of said Freight Terminal and appurtenant facilities.

(a) It is understood that any employee shall be removed from service in said Freight Terminal upon the written request of the..."B"...Company.

(b) The employees engaged in said Freight Terminal shall make such reports to the..."B"...Company from time to time as it may reasonably require, and any monies collected for the ..."B"...Company shall be considered as its funds and remitted as it may direct. The..."A"...Company shall not be responsible in any way for such collections and remittances and only agrees to use ordinary care in the selection of its employees.

(c) The..."B"...Company may bond any employee in said Freight Terminal it desires or may join with the..."A"...Company in bonding any such employee.

4. The..."B"...Company shall at its sole expense and as directed by the..."A"...Company switch from or to said Interchange Tracks or such other tracks in said Freight Terminal as may be designated from time to time by the..."A"...Company cars empty or containing freight handled or to be handled by the..."A"...Company for account of the..."B"... Company at said Freight Terminal.

The..."A"...Company shall inspect all cars placed on said Interchange Tracks for itself and for the..."B"...Company in accordance with the rules of the American Railway Association.

(a) A car brought into said Freight Terminal by either party, for delivery to the other party, empty or containing freight solely for such other party, shall be considered delivered with its contents, if any, as soon as it has been placed on said Interchange Tracks, and has passed inspection.

(b) A car brought into said Freight Terminal by either party, containing freight for local delivery, or for transfer, or both, and freight for the other party shall be considered delivered with its contents to such other party as soon as the freight of such party has been removed therefrom.

(c) A car brought into said Freight Terminal by either party, containing freight for local delivery, or for transfer for such party, or both, shall, with its contents, be considered in possession of such party.

(d) An empty car in possession of either party placed in said Freight Terminal for loading and to be forwarded over the lines of the other party shall be considered delivered to such other party as soon as it has been so placed.

(e) Freight in a car brought into said Freight Terminal by either party for transfer to the other party shall be considered delivered as soon as it has been safely loaded into the car in possession of such other party.

(f) Notwithstanding any of the other provisions of this section, in matters of interchange, the American Railway Association's Per Diem Rules and Code of Rules Governing the Condition of, and Repair to, Cars shall apply.

5. The..."A"...Company shall maintain said Freight Terminal and appurtenant facilities in such a manner as may in its judgment be necessary; shall pay all taxes and assessments on said Freight Terminal and appurtenant facilities and premiums on such insurance thereon as may in its judgment be necessary; and shall provide the electrical energy, heat, water, telephone service and other accessories necessary in connection with the operation of said Freight Terminal; provided, however, that the ..."B".. Company shall, at its own cost and expense, furnish all special printed forms and stationery it may require for the conduct of its business.

Payments

6. The..."B"...Company shall pay to the..."A"...Company monthly for the privilege of using said Freight Terminal and appurtenant facilities and for the service performed for it by the..."A"...Company, the following sums of money:

For General Supervision of Freight Terminal, Use of Interchange Tracks, Inspection of Cars and Switching

A proportion of the costs and expenses of the following items to be determined by the ratio of the number of cars switched from and to said Interchange Tracks by the..."B"...Company to the total number of cars switched into and out of said Freight Terminal during such period.

(a) Interest at the rate of....per cent per annum upon the value of said Interchange Tracks including land which for the purpose of this agreement is hereby agreed to be $....

(b) The sum of $.... per annum representing reserve for retirement of said Interchange Tracks.

(c) Taxes and assessments on said Interchange Tracks.

(d) Expense of maintaining said Interchange Tracks.

(e) The wages paid by the..."A"...Company to the Agents, Yardmasters, Car Foremen, Inspectors, Special Agents and other employees not assigned to but whose services may be wholly or partially required in connection with the work or in the supervision of said Freight Terminal and appurtenant facilities.

(f) The cost of switching including rental of engine, wages of engine and train crews, engine repairs, fuel, water, supplies, engine house expenses and housing of engines.

For Use of Freight Station

A proportion of the costs and expenses of the following items to be determined by the ratio of the number of tons of L.C.L. freight handled at said Freight Station for account of the..."B"...Company to the total number of tons of L.C.L. freight handled at said Freight Station during such period.

(a) Interest at the rate of .... per cent per annum upon the value of said Freight Station including land which for the purpose of this agreement is hereby agreed to be $....

(b) The sum of $.... per annum representing reserve for retirement of the several component parts of said Freight Station.

(c) Taxes and assessments and premiums on said insurance on said Freight Station and the cost of electrical energy, heat, water, telephone service and other accessories at said Freight Station.

(d) The expense of maintaining said Freight Station.

(e) The wages paid by the...."A"...Company to the Agent, Clerks, Telegraph Operators, Laborers and other employees engaged at said Freight Station.

For Use of Transfer Platform

A proportion of the costs and expenses of the following items determined by the ratio of the number of tons of L.C.L. freight transferred for the..."B"...Company to the total number of tons of L.C.L. freight transferred at said Transfer Platform during such period.

(a) Interest at the rate of .... per cent per annum upon the value of said Transfer Platform including land which for the purpose of this agreement is hereby agreed to be $....

(b) The sum of $.... per annum representing reserve for retirement of said Transfer Platform.

(c) Taxes and assessments and premiums on said insurance on said Transfer Platform and the cost of electrical energy, heat, water, telephone service and other accessories at said Transfer Platform.

(d) The expense of maintaining said Transfer Platform.

(e) The wages paid by the..."A"...Company to the Foremen, Laborers, Clerks and other employees engaged in connection with transferring L.C.L. freight at said Transfer Platform.

For Use of Team Track Yard

A proportion of the costs and expenses of the following items determined by the ratio of the number of cars inbound and outbound handled for account of the ..."B"...Company to the total number of cars inbound and outbound handled in said Team Track Yard.

(a) Interest at the rate of .... per cent per annum upon the value of said Team Track Yard including land during such period which for the purpose of this agreement is hereby agreed to be $....

(b) The sum of $.... per annum representing reserve for retirement of said Team Track Yard.

(c) Taxes and assessments on said Team Track Yard and premiums on said insurance on said Team Track Yard Office and the cost of electrical energy, heat, water, telephone service and other accessories in connection with said Team Track Yard.

(d) The expense of maintaining said Team Track Yard.

(e) The wages paid by the..."A"...Company to the Clerks, and other employees engaged at said Team Track Yard.

For Use of Icing Station

A proportion of the costs and expenses of the following items determined by the ratio of the number of tons of ice furnished to cars for account of the..."B"...Company to the total number of tons of ice furnished to all cars from said Icing Station during such period.

(a) Interest at the rate of .... per cent per annum upon the value of said Icing Station including land which for the purpose of this agreement is hereby agreed to be $....

(b) The sum of $.... per annum representing reserve for retirement of said Icing Station.

(c) Taxes and assessments and premiums on said insurance on said Icing Station, and the cost of electrical energy, heat, water, telephone service and other accessories at said Icing Station.

(d) The expense of maintaining and operating said Icing Station.

(e) The wages paid by the..."A"...Company to the Foremen, Clerks, Laborers and other employees engaged at said Icing Station.

Bills rendered hereunder will include 10 per cent overhead charge on labor for supervision, transportation, accounting and similar items and 15 per cent overhead charge on materials for supervision, storehouse expense, transportation, accounting and similar items.

Bills are to be rendered monthly on or before the ..... day of each month and shall be paid within ..... days thereafter, and no bill shall remain unpaid for a longer period than ..... days, but it is agreed that if any items in said bills are not agreed to at the time paid they may be later adjusted but no account or bill shall be open for adjustment after it has been closed or paid for twelve months.

The..."B"...Company shall have the right to inspect the records and accounts of the..."A"...Company relating to the operation of said Freight Terminal at all reasonable times.

Additions and Betterments

7. In the event that any additions to, or betterments or improvements of, the facilities of the..."A"...Company to be jointly used by the..."B"... Company hereunder shall, at any time hereafter and during the life of this agreement, in the judgment of the..."A"...Company, be deemed to be necessary for the joint use of the parties hereto, then and in such event, the..."A"...Company may, in its discretion and without the concurrence of the..."B"...Company, make and construct the same, and thereafter the..."B"...Company shall pay additional interest at the rate hereinbefore provided on the cost of said additions and betterments as charged to the..."A"...Company's capital account in accordaance with the rules of the Interstate Commerce Commission and shall also pay a proportion of the cost of maintenance and operation of the same as hereinbefore provided.

Custody of Property

8. All cars of the..."B"...Company and the contents thereof, while upon the said tracks of the..."A"...Company, as well as all freights held by or for account of the..."B"...Company in, upon or about the said Freight House, Platform or other Terminal facilities of the..."A"... Company so as to be jointly used hereunder, as aforesaid, shall, for the purpose of this agreement, be deemed and considered to be under the control and in the custody and care of the..."B"...Company and the..."B"... Company shall carry its own fire insurance upon same.

9. The..."A"...Company shall provide for the movement of the freight cars of the..."B"...Company over its tracks as nearly as may be practicable in accordance with the request of the..."B"...Company, and shall exercise in the handling of such cars the same degree of care that it exercises in the handling of its own cars.

10. In case the..."B"...Company shall by reason of strike, riot, insurrections, civil or military authority, fire, explosion, Act of God or any other unavoidable casualty be deprived of the use of said facilities or any part thereof, a reduction of said rental shall be made to it for the time during which said deprivation shall continue, proportionate to the amount of said deprivation.

11. All employees of the..."A"...Company in said Freight Terminal hereinbefore provided for shall for the purpose of this agreement, be considered to be sole employees, in the performance of, or omission to perform, services, the benefit or other result of which accrues to either party hereto, solely; and as joint employees, in the performance of, or omission to perform, services, the benefit or other result of which accures to both parties hereto jointly.

Liability

12. Liability for all loss of or damage to property and injury to or death of persons (all hereinafter collectively referred to as damage), in any manner originating or occurring upon or in connection with the operation of the property and facilities covered by this agreement, and upon or in connection with any use made by the..."B"...Company of tracks and facilities of the..."A"...Company as access thereto, shall be governed by the following provisions:

Each party hereto shall be liable for all damage which shall be caused in any manner by or in connection with its business or traffic, when the business or traffic of the other party is in no wise involved.

Each party hereto shall be liable for all damage which shall be caused solely:

(a) By defect in its sole property or property separately used by it.
(b) By act or by the negligence of its separate employees.

Otherwise, each party shall be liable for all damage to its separate property, employees or traffic.

All other damages and costs and expenses in connection therewith, including those resulting from undetermined causes, shall be borne equally by the parties hereto.

Each party shall adjust the claims of its own employees. No settlement for which the other party is to be held wholly responsible, and no settlement in excess of Five Hundred Dollars ($500.00) for which the other party is to be held jointly responsible, shall be made without its concurrence.

In event of any suit being brought against either party hereto, for which the other party may be held liable, the party against whom such suit is brought shall at once give the other party notice in writing thereof in order that the other party may make such defense as it may deem proper, and in such case the party that is liable as herein provided shall pay all attorneys' fees, costs and expenses incurred in defending such suit, as well as damages that may be recovered therein.

Default

13. If the..."B"...Company shall make default in any of the payments hereinbefore required of it to be made, or shall fail to faithfully perform any of the covenants herein required by it to be performed, then in such case, and if such default or failure shall continue for a period of ..... (....) days after the ..."A"...Company shall have given the..."B"...Company a written notice thereof, the..."A"...Company may, by a ..... (....) days' notice in writing to the..."B"...Company, declare this agreement terminated, and may at the termination of the said ..... (....) days in said notice mentioned, exclude the..."B"...Company from the use and enjoyment of any and all of the premises and privileges hereunder and the..."B"...Company shall discontinue the use of all of said premises and privileges and shall have no claim or demand upon it by suit at law or otherwise, on account of such exclusion, provided, that failure to make any payment or perform any covenant which is the subject of arbitration or of litigation between the parties hereto, shall not, pending arbitration or litigation, be deemed a cause of forfeiture hereunder.

The..."A"...Company may waive any such default or failure, but no action of the..."A"...Company in waiving such default or failure shall extend to, or be taken to affect any subsequent default or failure, or impair its rights.

Arbitration

14. In case any question arises under this agreement or concerning the subject matter thereof, upon which the parties hereto cannot agree, such question may be settled by a sole disinterested arbitrator, to be selected jointly by the parties to this agreement.

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as may be determined by the arbitrator.

Term

15. This agreement shall take effect on the ..... day of ..... 19.... and, unless earlier terminated as hereinbefore prescribed, shall continue in force for the period of ..... years from said date and thereafter until terminated on a date specified by a written notice given to either party by the other party at least ..... prior to such date of termination.

This agreement shall inure to the benefit of and be binding upon the parties hereto, their successors and assigns, but no transfer or assignment shall be made by the..."B"...Company without the prior written consent of the..."A"...Company.

In Witness Whereof, the parties hereto have executed this agreement the day and year herein first above written.

.....		The ..... Company	
Attest		By	Seal
.....	.....	.....	A
	Secretary	President	Company
.....		The ..... Company	
Attest		By	Seal
.....	.....	.....	B
	Secretary	President	Company

Note:—In event the..."A"...Company shall permit any other railway company or companies to use said Freight Terminal and appurtenant facilities, then the proportion of liability under Section 12 assumed by the ..."B"...Company shall be determined by the ratio of one to the total number of companies using Freight Terminal and appurtenant facilities.

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(3) The Committee recommends that the Form of Agreement for Use of Railway Property for Public Highways as printed in Bulletin 293, page 463, be dropped from the outline of work because there seems to be no general need for such a form.

(6) The Committee has reviewed the points to be covered in an agreement between companies participating in a joint terminal project as set forth by Committee XIV on Yards and Terminals in Bulletin 294, page 582, and that Committee's report is found to include a complete list of items, no additional items being required.

The Committee recommend that the Form of Agreement for Joint Ownership, Use and Management of a Terminal Project be continued in the outline of work for the coming year, including the items recommended by Committee XIV with some rearrangement in their order and with proper modification of details.

Appendix C

(4) FORM OF CONSTRUCTION CONTRACT FOR PARTICULAR ITEMS OF WORK

(5) FORM OF COST-PLUS PERCENTAGE CONSTRUCTION CONTRACT

Clark Dillenbeck, Chairman, Sub-Committee; C. Frank Allen, H. E. Barlow, W. H. Brameld, B. S. Dickerson, B. Herman, F. L. Nicholson, Huntington Smith, John Worley.

(4) FORM OF CONSTRUCTION CONTRACT FOR PARTICULAR ITEMS OF WORK

Your Sub-Committee has made careful study of this subject and after preparing a tentative form reached the conclusion that such a form of Contract would consist of a copy of certain parts of Form of Construction Contract. It was further determined that the form would vary for different items of work, and it would be difficult to determine how much or how little of the Form of Construction Contract should be used in preparing such a standard form.

As a Contract for Particular Items of Work could readily be written by taking and using such parts of the Construction Contract as may be found necessary, your Committee recommends that this subject be discontinued and no such form prepared at this time.

(5) FORM OF COST-PLUS PERCENTAGE CONSTRUCTION CONTRACT

Your Sub-Committee has continued the study of this subject and has prepared a Form of Cost-Plus Percentage Construction Contract which is submitted herewith for information and discussion.

FORM OF COST-PLUS PERCENTAGE CONSTRUCTION CONTRACT

THIS CONTRACT, made this ..... day of ....., in the year ....., by and between ....., hereinafter called the Contractor, and ....., hereinafter called the Company.

WITNESSETH, That, in consideration of the covenants and agreements herein contained, to be performed by the parties hereto, and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

The Contractor shall furnish all the materials, superintendence, labor, tools, equipment, facilities, supplies and transportation except as hereinafter specified, and shall execute, construct and finish, in an expeditious, substantial, and workmanlike manner, to the satisfaction and acceptance of the Chief Engineer of the Company, all of the work required for.....
.....
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.....

in accordance with plans to be furnished by the Chief Engineer of the Company, or with plans completed at the time of the execution of this contract, identified by the signatures of the Contractor and the Chief Engineer, dated..... 19...., and described .....
.....
.....
and the specifications hereto attached, all of which are made a part of this contract.

Time

The work covered by this contract shall be commenced on or before the ..... day of ....., 19...., and shall be completed on or before the ..... day of ....., 19....,
.....
.....
.....

And, Whereas, TIME being the essence of this contract and it is agreed that the Company would suffer loss by the failure of the Contractor to have said work completed in all its parts on said day, and as it might be difficult and expensive to accurately compute the amount of such loss; in order to avoid such expense and difficulty, the Contractor hereby expressly covenants and agrees to pay the Company the sum of ..... dollars per day for each and every day, Sundays and legal holidays only excepted, after said ..... day of ..... during or upon which the said work or any part thereof remains incomplete and unfinished, not as a penalty, but as the liquidated actual losses which the Company will suffer on account of any failure on the part of the Contractor to have the said work completed in all its parts on said day; and that any sum which may be due the Company for such losses may be deducted and retained by the Company from any balance which may be due the Contractor when the said work shall have been finished and accepted as hereinafter provided. It is, however, agreed that in case any failure to complete the said work or some part thereof on said day shall be due to any cause beyond the Contractor's control and for which the Chief Engineer has granted an extension of time, such delays form no part of the number of days for each and every one of which the Contractor is to pay to the Company the sum of ..... dollars, as herein specified.

And in consideration of the completion of the work described herein, and the fulfillment of all stipulations of this contract to the satisfaction and acceptance of the Chief Engineer of the Company, the Company shall pay, or cause to be paid, to the Contractor, the amounts due to the Contractor, based on the costs and percentage hereinafter set forth.

Intent of Plans and Specifications

1. All work that may be called for in the specifications and not shown on the plans, or shown on the plans and not called for in the specifications, shall be executed and furnished by the Contractor as if described in both these ways; and should any work or material be required which is not denoted in the specifications or plans, either directly or indirectly, but which is nevertheless necessary for the proper carrying out of the intent thereof, the Contractor is to understand the same to be implied and required, and shall perform all such work and furnish any such material as fully as if they were particularly delineated or described.

Contractor's Understanding

2. It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work,

the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this contract. No verbal agreement or conversation with any officer, agent, or employee of the Company, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

Consent to Transfer

3. The Contractor shall not let or transfer this contract or any part thereof (except for the furnishing and delivery of material) without consent of the Chief Engineer, given in writing. Such consent does not release or relieve the Contractor from any obligations and liabilities under this contract.

Engineer and Chief Engineer

4. Wherever in this contract the word Engineer is used, it shall be understood as referring to the Chief Engineer of the Company, acting personally or through an assistant duly authorized in writing for such act by the Chief Engineer, and wherever the words Chief Engineer are used it shall be understood as referring to the Chief Engineer in person, and not to any assistant engineer.

Power of Engineer

5. The Engineer shall have power to reject or condemn all work or material which does not conform to this contract; to direct the application of forces to any portion of the work which, in his judgment, requires it; to order the force increased or diminished, and to decide questions which arise between the parties relative to the execution of the work.

Waiver

6. It is expressly understood and agreed that any waiver on the part of the Company or the Engineer, of any term, provision or covenant of this contract, shall not constitute a precedent, nor bind the Company or the Engineer to a waiver of any succeeding breach of the same or any other of the terms, provisions or covenants of this contract.

Adjustment of Dispute

7. All questions or controversies which may arise between the Contractor and the Company, under or in reference to this contract, shall be subject to the decision of the Chief Engineer, and his decision shall be final and conclusive upon both parties.

Permits

8. Permits of a temporary nature necessary for the prosecution of the work shall be secured by the Contractor.

Permits for permanent structures or permanent changes in existing facilities shall be secured and paid for by the Company.

Fire Insurance

9. The Contractor shall secure in the name of the Company, policies of fire insurance in amount, form and companies, satisfactory to the Chief Engineer, upon such structures and material as shall be specified by the latter, payable to the Company for the benefit of the Contractor or the Company as the Chief Engineer shall find their interests to appear.

Workmen's Compensation Insurance

10. The Contractor shall comply with all the laws of the State where the contract is to be performed, arising under any "Workmen's Compensa-

tion Act," and shall at all times carry and pay the premiums on all policies of insurance required by the laws of the State where the work is being performed, under any "Workmen's Compensation Act," so that the Company shall be fully protected from any and all claims for damages for personal injury, including death, which may arise from operations under this contract, whether such operations be by himself, or by any sub-contractor, or anyone directly or indirectly employed by either of them. Certificates of such insurance shall be filed with the Chief Engineer, if he so requires, and shall be subject to his approval for adequacy of protection.

Indemnity

11. The Contractor shall indemnify and save harmless the Company from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description made, brought or recovered against the Company by reason of any act or omission of the Contractor, his agents or employees, in the execution of the work, or in guarding the same.

Superintendence

12. The Contractor shall constantly superintend all of the work embraced in this contract, in person or by a duly authorized representative acceptable to the Company.

Notice—How Served

13. Any notice to be given by the Company to the Contractor under this contract shall be deemed to be served if the same be delivered to the person in charge of the office used by the Contractor, or to his representative at or near the work, or deposited in the postoffice, postpaid, addressed to the Contractor at his last known place of business.

Protection

14. Whenever the local conditions, laws or ordinances require, the Contractor shall furnish and maintain necessary passageways, guard fences, lights and such other facilities and means of protection as may be required.

Work Adjacent to Railway or Other Property

15. Wherever the work embraced in this contract is near the tracks, structures or buildings of the Company or of other railways, or persons, the Contractor shall use proper care and vigilance to avoid injury to persons or property. The work shall be so conducted as not to interfere with the movement of trains or other operations of the railway; or, if in any case such interference be necessary, the Contractor shall not proceed until he has first obtained specific authority and directions therefor from the proper designated officer of the Company and has the approval of the Engineer.

Rights of Various Interests

16. Wherever work being done by Company forces or by other contractors is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

Order and Discipline

17. The Contractor shall at all times enforce strict discipline and good order among his employees and any employee of the Contractor who shall appear to be incompetent, disorderly or intemperate, or in any other way disqualified for or unfaithful to the work entrusted to him, shall be discharged immediately on the request of the Engineer,

and he shall not again be employed on the work without the Engineer's written consent.

Contractor Not to Hire Company's Employees

18. The Contractor shall not employ or hire any of the Company's employees without the permission of the Engineer.

Unavoidable Delays; Extension of Time on Parts of Work

19. If the Contractor shall be delayed in the performance of the work from any cause beyond his control, he may, upon written application to the Chief Engineer within three days of such delay be granted such extension of time as the Chief Engineer shall deem equitable and just.

Tools, Equipment and Labor

20. The Contractor shall provide a full and ample supply of the best and most suitable equipment, tools, and supplies required for the performance of the entire work covered by this agreement, and provide material of every kind that may be needed for the thorough and expeditious execution of said work, and furnish and provide in sufficient numbers at all times, all mechanics, laborers, and other workmen necessary and requisite for the construction and completion of the whole of the work herein agreed upon to be done.

Sub-Contractor

21. The Contractor shall procure and submit to the Chief Engineer competitive proposals, from such sub-contractors as are mutually agreed upon, for items of work to be sub-contracted. From these competitive proposals the Chief Engineer shall select the sub-contractors to perform the work, and when so selected the Contractor shall enter into a contract with each sub-contractor in a form mutually approved by the Contractor and the Chief Engineer.

Upon award of any sub-contract as hereinabove provided, the dealings of the sub-contractor shall be directly with the Contractor, who shall be responsible for the carrying out of the work in accordance with the terms of this agreement, and shall superintend, supervise, and direct the entire construction of the work, and the character of the materials furnished and used, and shall coordinate the performance of all the various sub-contracts so that the entire work will proceed in an efficient, workmanlike and economical manner.

Routing Shipments

22. The Contractor shall ship all materials entering into the work and the tools, supplies and equipment required over the lines of the Company or allied interests wherever the freight rate is the same or less than by a competing line.

Test of Materials

23. The Contractor shall furnish the Chief Engineer, if requested, samples of any and all materials to be used in the prosecution of the work, for the purpose of making such tests as may be desired, and shall see that the materials thereafter furnished are in strict accordance with the approval of such samples.

Changes

24. The Chief Engineer shall have the right to make any changes that may be hereafter determined upon, in the nature or dimensions of the work, either before or after its commencement, and such changes shall in no way affect or void the obligations of this contract. Should such alterations diminish the quantity or extent of the work to be done, they shall

not constitute a claim for damages, on any ground whatever, including anticipated profits, in respect to the work which may be altered or dispensed with.

Suspension or Termination

25. The Company reserves the right to suspend or terminate the work embraced in this contract for reasons not herein specified, and the Contractor hereby agrees to discontinue all work within ..... days after receiving notice of such suspension or termination. In the event of such suspension or termination, the Contractor shall be entitled to payment in full of the cost of the work done to the date of suspension, plus the percentage thereon hereinafter provided for, and plus also the actual cost to the Contractor of being relieved from further liability with respect to commitments actually entered into prior to date of notice of such suspension or termination; it being agreed, however, that the Contractor will make no voluntary settlement with any sub-contractor or any other party to whom commitment is due without the approval of the Chief Engineer, and it being agreed further that the Contractor shall make no claim for consequential damages or anticipated profits upon work not actually performed, or damage of any kind resulting from such suspension or termination.

Accounts and Records

26. The Contractor shall keep accurate and detailed accounts of all disbursements in form satisfactory to the Company, and shall give the Company access at any or all times to its books pertaining to the execution of same. If the Company desires, it shall have the right to place competent employees in any position of accounting or checking, in which event such employees shall perform their respective duties in accordance with the method in handling the work adopted by the Contractor, and the Contractor shall furnish monthly statements accompanied by such original bills or invoices certifying to the expenditures incurred under this contract. as may be required by the Company.

Cancellation

27. If at any time during the progress of the work it shall appear to the Chief Engineer that the work is not progressing with reasonable speed, or the quantity or quality of the tools, equipment and labor provided, or work done or materials furnished are not respectively such as to insure the completion of the work in accordance with the terms of this agreement, or that the work is not being prosecuted by the Contractor in an intelligent and workmanlike manner, or that legal proceedings have been instituted by parties other than the Company against the Contractor, in such a manner as to interfere with the prosecution of the work, or to subject the Company in making payments under this agreement to the peril of litigation, or that the Contractor is failing in any manner to observe and perform this agreement, then and in that case, the Chief Engineer may, by a writing, served upon the Contractor, declare this agreement terminated and annulled, and from the time of such service this agreement and every part thereof shall cease and terminate, and the Company may thereupon take possession of the said work or any part thereof, with the tools, equipment and other appurtenances for the completion of said work. In the event, however, of the Company utilizing the tools, equipment and other appurtenances of the Contractor for the completion of the work, the Contractor will be entitled to and shall receive the rental charges as provided for under this contract, until such time as the work is completed and the said tools, appliances, equipment and appurtenances are no longer required for the carrying out of the work.

COSTS

Labor Cost

28. The "Labor Cost," to which the percentage bid by the Contractor shall be added, shall be the actual payroll costs for all fieldmen employed by the Contractor in connection with work, and shall include the cost of loading plant, tools and equipment for shipment to the site of the work and unloading at the site, the cost for loading same upon completion of the work for shipment to the Contractor's store yard and unloading at the store yard. Nothing shall be added to said labor costs for Contractor's profit, for general expenses and salaries of his officers who do not devote their entire time to the work covered by this contract or for the wages of any person or persons employed in the home office or any regularly established branch office of the Contractor.

Material Cost

29. The "Material Cost," to which the percentage bid by the Contractor shall be added, shall be the actual cost as indicated by the original receipted bills rendered by the seller to the Contractor, and approved by the Chief Engineer or his Engineer in charge of the work, after having been awarded by the Contractor to the lowest bidder from at least three tenders submitted by reputable merchants, provided the said materials can be furnished within the time required for the proper prosecution of the work, and are of the prescribed quality.

Sub-Contracts

30. The cost of sub-contracts, to which the percentage bid by the Contractor shall be added, shall be the actual cost as per original bills and (or) payrolls, rendered by the sub-contractor and approved by the said Chief Engineer, or his Engineer in charge of the work, after having been awarded by the Contractor under terms and conditions as hereinbefore expressed.

Plant Rental

31. The rental of plant and equipment shall be in accordance with prices hereinafter provided for and shall cover rental of plant and equipment exclusive of small tools and perishable equipment hereinafter provided for, and hand tools owned by workmen.

When such plant and equipment shall arrive at the work, it shall be in sound and workable condition, and shall be subject to approval of the Chief Engineer as to its fitness and condition for the work to be performed, and the Contractor and the Chief Engineer shall agree upon a fair valuation at that time of each part of such plant and equipment. When the rental paid by the Company for the plant and equipment or parts thereof owned by the Contractor amount to ..... of the total value thereof determined as hereinbefore described, no further rental shall be paid on such plant, equipment or parts thereof, and the title thereof shall vest in the Company.

The rental for plant and equipment shall commence with the date it is first placed in operation on the work, and shall be continuous, including Sundays and holidays, until such time as the Chief Engineer or his Engineer in charge of the work decides it is no longer necessary for the proper prosecution of the work, which decision shall be stated in writing to the Contractor.

Small Tools Purchased

32. Small tools and perishable equipment for which no rental is to be paid shall be currently inventoried by the Contractor to the Company at

prices satisfactory to the Chief Engineer, and upon completion of the work, any tools or perishable equipment in usable condition shall be either retained by the Company or resold to the Contractor at prices fixed by the Chief Engineer.

Repairs to Plant

33. The cost of running repairs to plant and equipment will be considered as part of the cost of the work, and the Contractor will be reimbursed for same in accordance with the terms hereof, but no repairs constituting "major repairs" shall be included in the cost of this work or the Contractor be reimbursed for same, without first obtaining approval of the Chief Engineer.

Operation of Plant

34. The cost of labor for the operation of plant and equipment and the cost of labor for running repairs in the field, shall be paid for on the basis of labor cost hereinbefore referred to.

Overtime Plant

35. The schedule of rates hereinafter enumerated for rental of plant and equipment are on the basis of a single shift constituting the regular working hours of the "labor." Plant and equipment used for double shift will be paid for at one and one-fourth times the per diem schedule of rates so provided for, and plant and equipment which may not be temporarily in use or held on the work by the Contractor available for use with the approval of the Chief Engineer, will be paid for at one-half the per diem schedule of rates.

Costs to Which the Percentage Bid by the Contractor Shall Not be Added

The following items of cost incurred by the Contractor shall be paid by the Company, but without the addition of percentage bid.

Freight

36. Freight on plant and equipment from the store yard of the Contractor to the site of the work and return from the site of the work to the said store yard, or freight on plant and equipment shipped from some point other than the store yard of the Contractor to the site of the work and return to the Contractor's store yard.

Demurrage

37. Demurrage on cars containing plant and equipment, or material, when such charges are unavoidable, or when cars are held by order of the Chief Engineer.

Work Train

38. The cost of work train service furnished by the Company if paid for by the Contractor.

Watchmen

39. The cost of watchmen and flagmen furnished by the Company if paid for by the Contractor.

Plant Rental

40. Fixed prices for rental of plant and equipment.

Fuel, etc.

41. The cost of fuel, lubricants, materials, supplies and accessories necessary for the operation and repairs of the plant and equipment.

Miscellaneous Expenses

42. Miscellaneous expenses of the Contractor, such as telephone and telegraph tolls, solely in connection with the work, railroad fares and personal expenses of Resident Engineers, Superintendents, timekeepers, foremen and other employees at the field office of the Contractor.

PAYMENTS

Monthly Estimates

43. During the progress of the work, so long as the Contractor shall fully comply with the terms of this contract, the Company shall and will upon or about the ..... day of each calendar month make to the Contractor payment for and on account of the cost of the work done, materials furnished and delivered to the site of the work and rental of plant and equipment during the past preceding calendar month in accordance with the terms and conditions hereinbefore expressed, to which shall be added a fee of ..... with the exceptions hereinbefore noted at the following schedule for labor, plant and equipment rentals: .....
.....
.....
.....
.....
.....
.....

In the absence of any specific rate or rates in the above schedule, the Contractor shall apply to and obtain the approval of the Chief Engineer of such rate or rates required before putting same in force.

This contract shall inure to the benefit of and be binding upon the legal representatives and successors of the parties respectively.

In Witness Whereof, the parties hereto have executed this contract in ..... the day and year first above written.

Witness

.....

.....
Contractor.

Attest

.....
Secretary.

.....Company
President.

REPORT OF COMMITTEE XIII—WATER SERVICE

C. R. Knowles, *Chairman;*
C. M. Bardwell,
W. M. Barr,
S. C. Beach,
O. W. Carrick,
R. W. Chorley,
R. E. Coughlan,
J. H. Davidson,
B. W. DeGeer,
L. E. Elliott,
H. W. Faus,
J. M. Fitzgerald,
E. M. Grime,
J. P. Hanley,
J. R. Hickox,
R. L. Holmes,
S. C. Johnson,
F. H. Kornfeld,
R. C. Bardwell, *Vice-Chairman;*
C. H. Koyl,
P. M. LaBach,
E. G. Lane,
W. B. McCaleb,
A. B. Pierce,
O. T. Rees,
H. H. Richardson,
R. W. Savidge,
T. D. Sedwick,
H. E. Silcox,
D. A. Steel,
R. A. Tanner,
H. W. VanHovenberg,
J. B. Wesley,
A. E. Willahan,
D. Wood,
F. D. Yeaton,

Committee.

To the American Railway Engineering Association:

Your Committee on Water Service presents below its report to the Twenty-Ninth Annual Convention on the following subjects:

(1) Revision of the Manual.
Report of Sub-Committee on this subject appears in Appendix A.

(2) Drinking Water Supply on Trains and Premises of Railways.
Progress report on this subject appears in Appendix B.

(3) Pitting and Corrosion of Boiler Tubes and Sheets.
Progress report on this subject is submitted in Appendix C.

(4) Value of Water Treatment and Comparison of Methods.
Progress report on this subject is submitted in Appendix D (1), D (2) and D (3).

(5) Report on Various Types of Hydrants for Coach Yard and General Service.
Final report appears in Appendix E.

(6) Most Suitable Kinds and Types of Pipe for Small Service Lines.
Final report on this subject is submitted in Appendix F.

(7) Use of Gravity and Pressure Filters.
Committee reports progress under Appendix G.

(8) Methods for Disposal of Sludge at Water Softening Plants.
A final report is submitted in Appendix H.

(9) Design and Maintenance of Track Pans for Locomotives.
Progress is reported in Appendix I.

(10) Methods Used in Obtaining Successful Wells in Fine Sand Formation.
Progress report on this subject appears in Appendix J.

(11) Proper Spacing of Water Stations in Capacity of Engine Tenders.
A final report is submitted in Appendix K.

(12) Outline of Work for Coming Year.

A

Action Recommended

Your Committee recommends the following action on its report:

(1) That the examination of subject-matter in the Manual be again referred to the Committee for further study and report.

(2) That the report on the progress of drinking water regulations be received as information and that the subject be reassigned to the Committee for further study and report.

(3) That the report on pitting and corrosion of boiler tubes and sheets be reassigned to the Committee for further study and report.

(4) That the progress report on the value of water treatment and methods followed in treatment of water be accepted as information and the subject reassigned to the Committee for further study and report.

(5) That the final report on design of hydrants for coach yard and general service be accepted as information.

(6) That the report on the most suitable kinds and types of pipe for small service lines be accepted as information.

(7) That the subject on use of gravity and pressure filters be reassigned to the Committee for further study and report.

(8) That the final report on methods for disposal of sludge at water softening plants be accepted as information.

(9) That the report on the design and maintenance of track pans be reassigned to the Committee for further study and final report.

(10) That the subject on the best methods to be used in obtaining wells in fine sand formation be reassigned to the Committee for further study and final report.

(11) That the final report on proper spacing of water stations and capacity of engine tenders be accepted as information.

Suggested Subjects for Next Year's Study and Report

(1) Continue study of subject-matter in the Manual with a view to recommendations for changes.

(2) Continue study of progress of regulations of Federal and State authorities pertaining to drinking water supplies.

(3) Continue the study and report on the causes and extent of pitting and corrosion of locomotive boiler tubes and sheets, giving consideration to quality of water, character of metals, methods of manufacture, and types of boiler construction.

(4) Continue study on the cost of impurities in locomotive water supply and value of water treatment, with particular reference to the following phases of the subject:

(a) Study and report on methods of treatment where complete lime and soda-ash treating plants cannot be justified, or pending their construction.

(b) Review progress in water treatment on railroads and report on possible future development.

(5) Study and report on protective coatings for steel water tanks and underground pipe lines.

(6) Study and report on incrustation in pipe lines and methods of prevention, particularly where treated water is used.

(7) Continue study and make final report on the use of gravity and pressure filters.

(8) Study and report on fire protection and prevention at water stations, taking into consideration type of construction, power used, and fire protection appliances.

(9) Continue study and make final report on the design and maintenance of track pans for locomotive supply.

(10) Continue study and make final report on methods used in securing successful wells in fine sand formation.

(11) Study and report on water columns, their advantages over tank spout delivery, required range of operation, type of pit, and relative merits of rigid and telescopic spouts.

(12) Outline of work for ensuing year.

Respectfully submitted,

The Committee on Water Service,

C. R. Knowles, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

C. R. Knowles, Chairman, Sub-Committee; E. M. Grime, D. A. Steel.

The work of this Committee has consisted of a study of the subject-matter in co-operation with Committee XII—Rules and Organization, in establishing rules for the guidance of Water Service employees in the Maintenance of Way Department, and the rearrangement of subject-matter in the Manual. The work on Rules and Organization appears in the report of Committee XII.

Appendix B

(2) DRINKING WATER CONDITIONS ON RAILROADS DURING MISSISSIPPI FLOOD

Dr. S. C. Beach, Chairman, Sub-Committee; H. W. Van Hovenberg, A. B. Pierce, O. T. Rees, C. M. Bardwell, S. C. Johnson, L. E. Elliott, J. B. Wesley.

Taxed beyond their capacity by an unprecedented volume of water, breaks occurred in the levees on both sides of the Mississippi River in April and May, 1927, causing the most disastrous flood in the history of the Mississippi Valley, inundating 101 counties in seven states, a total of 18,000 square miles and driving three-quarters of a million people from their homes.

Not the least of the problems involved in connection with a flood of this magnitude is the question of drinking water supply; fortunately some of the more progressive railroads which were directly involved in this flood had trained sanitary personnel regularly employed who immediately began work on the protection of drinking water supplies, being assisted in many instances by untrained workers who volunteered their services and acted under instructions, thus enabling the work to be extended over greater territory.

With the prospect of countless cases of typhoid due to contaminated drinking water and every reason to believe that such cases might occur, yet the number was comparatively few among people who had disregarded the warning of the authorities or were hopelessly ignorant of their danger and not in a position to even boil such water supplies as could be obtained. Never has the value of chlorinating drinking water supplies been so well demonstrated as during this disastrous overflow of the Mississippi and it is to be remembered that it was started early, both quantity chlorination and for individuals and families as well. It preceded the formation of the splendid refugee camps which were soon started and accompanied the sanitary regime of such camps until they were able to procure drinking water rendered safe for the use of the thousands cared for at such camps and even then the process of sterilization was chlorination.

When one remembers that the wholesale anti-typhoid innoculation which was given in the camps did not re-act until nearly a week after the last or third innoculation before immunity occurred, the time of the innoculations occupying from one and a half to three weeks, it will be readily seen the value of water sterilization cannot be overestimated.

Where the drinking water supply is derived from driven or drilled wells or even properly constructed dug wells, or is a river supply properly filtered and sterilized, and all sources depended upon existed in the flooded states, even then contamination took place due to the height of the waters and the force of the currents; few, if any, of the flooded towns escape damage to their water plants and widespread contamination of their drinking water and it was only by careful laboratory tests, all of which took time,

that the safety of the water could be determined. If the source of the water happened to be an untreated surface supply, flood conditions made but little change since even under ordinary conditions surface water supplies cannot be considered safe.

In accord with universal custom, the people were told to boil the water but investigation revealed that few of them followed instructions. Simultaneously with instructions to boil water arrangements were made to extemporaneously chlorinate a quantity of water with chloride of lime, always easily obtainable even in the small town. This treated water was placed in containers easily accessible and instructions were given to obtain and drink water from these containers. This was followed by house-to-house instructions in the use of a furnished solution of chlorinated lime, the houses during flood time consisting largely of box cars furnished by the railroads to refugees. By a careful supervision of these methods the majority of the refugees drank only treated water and by passing along the information to newcomers with emphasis on the dangers of drinking flood water untreated, it was possible to keep the number of people using contaminated water down to a very small number.

It was found that private wells of the drilled or driven type which were adequately protected at the top so that flood waters could not enter them continued to give a safe water, as was determined by laboratory tests. Dug wells were always regarded with suspicion and only under exceptional circumstances furnished a safe water. Most of these wells within the flooded area were of the shallow dug type, especially in the rural and small town districts and were badly contaminated during the flood. Numbers of such wells were found to be unsafe even during normal conditions existing after the flood by reason of improper construction and close proximity to privies and other sources of pollution. Proper methods of constructing wells can be obtained from American Railway Engineering Association Bulletin 270.

Flooded wells should be chlorinated as soon as conditions allow, using an ounce of hypochlorite to each thousand gallons of well water, the chemical first being dissolved in a small quantity of water and then thrown into the well, mixing thoroughly by continued agitation. After half an hour the water may be considered as ready for drinking and safe for human consumption. The water may have a slight taste but this is not harmful and is even desirable, the taste of the chlorine being an index that the water has been properly sterilized. As soon as the taste of the chlorine begins to grow faint, the doseage should be repeated, for it is to be remembered that the water in the well is constantly changing as it is renewed from its source and must, therefore, be kept chlorinated. It is well to pump out the water completely as soon as conditions allow, giving the entire lining of the well thorough scrubbing with milk of lime and then allowing the well to refill to its former level, at once chlorinating this new supply in the same manner as was originally done.

Cisterns should be treated in a precisely similar manner where there exists the least doubt as to the safety of the water.

The Illinois Central System put out a bulletin (Revised Circular No. 24) containing instructions for the use of chloride of lime in the extemporaneous treatment of drinking water, directing the use of a "level tablespoonful" to the quart of water. This gives a 120 to 150 grain solution, one tablespoonful of which was added to ten gallons of water, thoroughly stirred and allowed to stand twenty minutes to one-half hour before using. This makes three-parts-per-million chlorination which should render even badly contaminated water safe providing sufficient attention be given to the thorough mixing and allowing the mixture to stand a sufficient time. The circular was much used during the prevalence of the Mississippi overflow. It must be realized as a fundamental point that impure or contaminated drinking water such as existed during the overflow is the most common cause of typhoid and other intestinal disturbances and that not only public water supplies of cities and towns but thousands of private supplies were rendered unsafe. The railroads faced a most serious condition involving not only the town and city public supplies from which drinking water must be obtained for laborers but hundreds of isolated and moving groups had constantly to be furnished with safe drinking water, these being the army of men who worked on the immense task of repairing damages caused by the flood and composed not only of track and other laborers but scores of highly paid and skilled directors of the vast work undertaken.

Fortunately some of the supplies which were derived from properly drilled or driven wells and even supplies taken from the Mississippi where properly filtered and sterilized and these useful adjuncts had not been put out of commission by the fury of the flood, and remained safe for public use; their number, however, was small.

The State Health Departments installed a number of emergency liquid chlorinating machines in some of the larger towns, this step becoming necessary on account of the damage to the pumping plants supplying these towns. Tests made on waters of towns so equipped often showed contamination and investigation showed that the inhabitants did not follow instructions and allowed their hydrants to run for twenty minutes or half an hour, so as to drain off the contaminated water in the service pipes; the feeling that good water was precious and must be conserved had taken possession of them and some vigorous efforts were put forth before this difficulty was overcome.

Until good water supply conditions have become firmly established after a flooded period, it is well to have barrels or tubs of treated and sterilized water placed in several easily accessible places in the town or community from which the citizens may obtain their water supply and no one should be allowed to use water from any other source. This is similar to methods used in the army where portable canvas bags were suspended at suitable points and filled with treated sterilized water, the chemical used being chloride of lime.

Early in the flood the railroads in the troubled territory issued instructions for sterilizing water from wells, cisterns or springs, running about as follows: Water from wells, cisterns or springs subject to contamination

should be sterilized before it is used for drinking or culinary purposes. The shortest and easiest method of sterilization is to boil the water for ten or fifteen minutes, timing from the instant that the water comes to boiling point; the flat taste which is left from boiling may be removed by pouring from vessel to vessel and thus mixing with air, or by adding a pinch of table salt.

As it is not always convenient or possible to boil a large amount of water, the use of chloride of lime may be substituted, this chemical being put up in sealed tins. The chemical deteriorates somewhat on standing, even in its sealed tin box, but should give off a decidedly pungent smell when opened in proof of its chlorine content.

One ounce of chloride of lime should be used to every thousand gallons of water to be treated, making about a two-part-per-million solution. If scales are not available an ordinary tablespoon may be used, two heaping tablespoonsful weighing approximately an ounce. Rub up the dry powder with a small amount of water to form a paste, carefully breaking up the lumps and adding enough water to make the paste of pouring consistency, then empty into a bucket of water, stirring constantly until thoroughly mixed. It is well to perform this operation out-of-doors or in a good draft in order to avoid inhaling the chlorine fumes which are evolved but which cannot be considered harmful nor poisonous. Pour the bucketful of solution into the well and either stir with a clean board or raise and lower the well-bucket a sufficient number of times to thoroughly mix the solution with the well water; water from this well should not be used for about half an hour in order to allow sterilization to become thorough.

Chloride of lime contains about one-third available chlorine and the above treatment corresponds to about two and one-half parts per million dosage with chlorine. This amount should impart a slight taste to the water, harmless however, and even reassuring to the user, inasmuch as it indicates that sufficient chlorine has been added. Unless this taste is present in addition to a slightly pungent odor it is well to repeat the dosage using about one-half the former quantity.

It must be borne in mind that such a procedure will sterilize only the water actually present in the well at the time of treatment; when it is estimated that this amount of water has been withdrawn the chlorinating process should be repeated, especially when through defective walls, faulty construction or insanitary surroundings, it is felt that contributory contaminative seepage is taking place.

The following table has been devised to enable the fieldman to rapidly estimate the amount of water present in the well which is being chlorinated:

Diameter of well in feet.....	1	2	3	4	5	6	7	8
Gallons for each foot depth of water...	6	24	53	94	147	212	288	376

The United States Army Medical Corps have found that two drops of 7 per cent tincture of iodine added to a quart of water will destroy all germ life in one-half hour, rendering the water safe for drinking purposes. It is well to bear in mind that any process of sterilization is, at best, only a temporary measure and that immediate steps should be taken to remove contaminative influences.

While much has been said concerning chloride of lime it is not the only chemical which may be used for water sterilization, there being several on the market which were used in the overflow with success and which are equally efficient, most of them, however, being dependent upon their chlorine content for sterilizant effect.

When it is realized that the breaks in the levees inundated 18,000 square miles in seven southern states and rendered homeless three-quarters of a million people, not only destroying their properties and endangering their lives but covering the land with from ten to twenty feet of swirling, muddy, swift-currented flood water containing the bodies of decomposing animals and other refuse defying description, the magnitude of the problem becomes apparent.

This flood water covered the dug, driven and drilled wells and arose so high as to put out of commission many of the pumping plants; thus the very source of the domestic water supply was shut off and the sufferers forced in many localities to drink the flood water. The unsubmerged portions of land were crowded with human beings and stock, the resulting condition as regards sanitation being indescribable. Even fuel was scarce, thus limiting the building of fires over which to cook the scanty food, much less boil the filthy flood water and thus render it reasonably safe for drinking.

Under these trying circumstances chlorinated lime became a prophylactic necessity and under supervision of trained workers was put to good use in the sterilization of drinking water, a stock solution being carried and given to small groups with instructions for its proper use. Measured portions of this were added to the water to be used for drinking and after standing for a time, the mixture could be used with safety. For larger groups where a greater quantity was needed, tanks were used containing a solution of an ounce of the chloride of lime to the thousand gallons of water and in the municipalities having water works, an emergency chlorinator using liquid chlorine was used, the inhabitants being directed to flush their hydrants for half an hour before venturing to use the city water.

It is to be noted with pride that the railroad companies involved in the flooded areas were working literally night and day for the aid and relief of the unfortunate victims of this the most devastating flood ever occurring in the Mississippi Valley in recent years; refugees were hauled out freely, supplies were hauled in same way and often the relief train carried its freight, both human and otherwise, over tracks which were covered by 20 inches of water, it being barely possible for the locomotive to make headway. Even when forced to suspend sending trains through, motor boats were placed in service and the work of aid and relief continued without intermission, the efforts of these companies proving a godsend to the beleagured inhabitants. Later in the fight every able-bodied railroad man who had experience with disaster conditions flocked into the country to help in any way he could, the trained sanitarians being especially useful in fighting the possibilities of after-coming disease and instructing the people in proper preventive measures.

Appendix C

(3) PITTING AND CORROSION OF BOILER TUBES AND SHEETS

In the absence of a progress report by the Committee, monographs have been prepared by Messrs. C. H. Koyl, of the Chicago, Milwaukee & St. Paul, and L. O. Gunderson, of the Chicago & Alton, outlining certain more or less well-known principles of corrosion, and describing methods followed on those two roads in efforts to prevent pitting and corrosion.

These monographs are submitted as information.

CAUSES OF BOILER PITTING AND MEANS OF PREVENTION IN NEUTRAL AND ALKALINE WATERS

By C. H. Koyl, Engineer Water Service, Chicago, Milwaukee & St. Paul Railway

The problem of boiler pitting is now more than sixty years old.

When a problem has waited thus long for solution, it requires no argument to prove that something has been lacking in careful observation of its characteristics or something in the theoretical knowledge applicable to it; and the study of the causes of locomotive boiler pitting has been hampered by both.

In the matter of observation, the principal difficulty has been the great complexity of the forms of pitting, due partly to the many different kinds of water (acid, neutral and alkaline) taken by a locomotive boiler during the months while the pitting is being effected; and the increase of knowledge during the last few years is partly due to having isolated some of these boilers and studied the kind of pitting produced by each kind of water alone.

In the matter of theoretical knowledge, the principal difficulty has been the lack of agreement among research chemists as to the fundamental factors and reactions of corrosion in general; and it is only within the last few years that agreement may be said to have been reached.

That corrosion in a boiler is due partly to the character of the water is proved by the everyday observation that boilers are corroded in some waters and not in others; and that it is due partly to inequalities in the metal is proved by the fact that the corrosion is not of uniform depth.

This Sub-Committee in its reports from 1921 to 1926 portrayed yearly the advancing state of knowledge as conclusions were definitely established, and these may be summarized now in non-technical language as follows, it being assumed that the reader has a general knowledge of the theory of the dissociation or ionization of acids, bases and salts in dilute solution in water:

(1) The purest iron dissolves slowly in the purest water. Each atom of iron that disappears in the water carries a definite positive electric charge (thus becoming an ion) and forces out from solution an ion of hydrogen. Even the purest of iron strips does not dissolve uniformly, and the released hydrogen atoms cling to the more slowly-dissolving parts. The passage of

an electric charge from the site of the pit into the water with each dissolving atom of iron, and the transfer of a similar electric charge to some adjacent point on the metal by the contact of the ion of hydrogen, which thus becomes an atom, constitutes an electric current, called electrolytic. The site of the pit whence the charge leaves is called the electro-positive or anodic surface, and the point at which the hydrogen ion arrives and gives up its charge is called the electro-negative or cathodic surface.

(2) When commercial steel constituting the flues and sheets of boilers, pits, the metallic iron from the pits is dissolved in the surrounding water, throwing out of solution a corresponding amount of ionic hydrogen which either clings to the adjacent metal or escapes to the surface of the water.

(3) Water can hold in solution only an infinitesimal amount of iron, and therefore the water becomes saturated with iron (reaches a state of equilibrium) and pitting stops before noticeable damage is done unless there is something in the water (acid or oxygen) to combine continuously with the dissolved iron, taking it out of solution and making room for more.

(4) The hydrogen liberated by the dissolving iron tends to cling to the cathodic iron surface and to destroy the difference of electric potential which dissolves the iron from the pit, so that on this account also (the formation of this protecting film of hydrogen on the unpitted surface, technically called polarization) pitting would stop in neutral or alkaline water were it not for dissolved oxygen in the water which combines readily with this hydrogen film and removes it.

Pitting therefore requires several conditions and a cycle of operations, and if we can destroy one of the conditions or one of the series of operations we can prevent the pitting.

(a) There must be difference of electric potential between parts of the boiler interior. This we have little hope of ever changing, because even if steel were absolutely uniform while hot, it segregates on cooling; and even if it were chemically uniform on cooling, the least little hammering or bending or strain of any kind sets up a difference of potential.

(b) There must be hydrogen ions in the water. Our reports from 1923 to 1926 show how the hydrogen ion concentration in boilers can be reduced to almost negligible proportions by keeping the water charged with sodium hydroxide to the amount of 15 per cent of the dissolved electrolyte. This is a simple matter in the case of waters softened by the lime-soda process, and is effectively used to prevent pitting on a few railroads; but it is difficult when using natural hard waters.

(c) For pitting to be continuous and harmful the metal must be kept free from any protecting cover like a hard dense scale, or like the film of hydrogen which naturally forms on clean flues and sheets. We cannot protect the metal with scale because it obstructs the flow of heat and wastes coal. But the natural film of hydrogen is a practically perfect protection and it can be kept on the metal surface by abstracting from the feedwater, before it reaches the boiler, the oxygen dissolved from the air, which if admitted to the boiler would combine with and destroy the hydrogen film.

Or the metal can be protected by an artificial film electro-negative to hydrogen.

Accounts of the successful use of the hydrogen film in a locomotive boiler on the Chicago, Milwaukee & St. Paul Railway for two years, and of the successful use of an artificial film in two locomotive boilers on the Chicago & Alton for three years, constitute our report and are found in the two following papers.

THE PREVENTION OF BOILER PITTING IN NEUTRAL AND ALKALINE WATERS BY THE EXCLUSION OF DISSOLVED OXYGEN FROM THE FEEDWATER

By C. H. Koyl, Engineer Water Service, Chicago, Milwaukee & St. Paul Railway

In the matter of boiler tubes, the duty of the boilerman in an engine house is to replace them so soon as, or just before, they become useless. But when one is studying the cause of boiler pitting it is necessary to withdraw some tubes at regular short intervals to observe the beginning and progress of the pitting, and it is necessary at such times to record the location of pits as to the position of the tube in the boiler and the location of the pit on the tube.

In 1918, on the Great Northern Railway, by such observations the boilermen soon established the fact that in water slightly acid from any cause, either coal-mine or swamp or sewage, the pitting commenced at the hot end of the boiler and gradually worked forward until, sometimes, it reached the front end before the tube became useless. And they noted also that in alkaline water the pitting commenced at the front end of the boiler and gradually worked back toward the hot end, sometimes reaching it before it was necessary to scrap the tube.

But on the main line running through North Dakota and Northern Montana we had for 700 miles a lime-soda water-treating plant at every water station and maintained the treated water, as it went to the boilers, at about 2 grains-per-gallon carbonate of lime, 6 grains caustic soda, and various amounts of sodium sulphate and chloride according to the original character of the water.

Before the water was treated, locomotive boiler pitting had been very bad, tubes lasting 9 to 10 months; and after treatment was in operation there was still more than enough pitting, tubes lasting about two years. But soon the boilermen began asking me why these treated-water tubes were pitted only on the front half, because apparently both tubes and water were the same from end to end of the boiler; why there were no pits on the tubes near the back flue-sheet where, on account of touching the copper ferrules, pitting is expected to be bad; and particularly why the switch engine tubes at Havre, Montana, lasted less than two years while the flues of the stationary boilers with a feedwater heater lasted easily four years. I was unable to answer at the time, but it was evident that there was more to boiler pitting than the electrolytic difference of potential

between hard spots and soft spots in steel, and between steel tubes and copper ferrules; and just as evidently the controlling factor in this case came into the boiler with the feedwater and was used up when the water was half-way back to the firebox.

After many examinations of the feedwater the conclusion was reached that the only active content of the water as it enters the boiler is oxygen dissolved from the air—one part per hundred of the water by volume, 12 parts per million by weight; and a study of the laboratory work of the research chemists made it plain. The originating cause of pitting is difference of electric potential between parts of the metal, but in any except acid water an oxidizing agent is necessary to the continuation of the pitting because something must take the iron out of solution before the water is saturated, and something must combine with the hydrogen which otherwise would cover the negative places on the metal and stop the process.

Since it was very probable that the oxygen which would have pitted the back half of the boiler had gone up into the steam-space by the time the water was half-way back to the firebox, it remained only to devise a means of depriving the feedwater of the principal part of its oxygen; and immediately the utilization of an open feedwater heater attached to the locomotive and heated by exhaust steam from the cylinders suggested itself. Such a heater would not only stop the pitting but would save $2000 in coal per year.

Measurements at the Altoona laboratory showed that under ideal conditions such a heater extracted about 90 per cent of the oxygen; and in April, 1925, on the Chicago, Milwaukee & St. Paul Railway, a locomotive with new tubes was fitted with an open feedwater heater and placed for test on one of our treated-water districts in South Dakota where formerly pitting was very bad, and where even with treated water and caustic soda averaging 40 grains-per-gallon between washings the tubes average only two years' service. For comparison, another engine with new tubes of approximately the same date, a mate in all respects except that it has no heater, has been on the same run.

At intervals of two months we have taken out a few tubes for examination from the locations where pitting is worst on other engines working on this district, and during the two-and-one-half years that the locomotive has been in service the boiler foreman has always reported "No pits; good for service."

During this time the mate engine has been pitting steadily, so that more than half her tubes are in the scrap heap.

It is known that under certain concentrations of hydrogen ions boilers will pit even in the absence of oxygen, but the dividing line has not been established, and this year we are fitting up four more locomotives in the same manner for tests on other districts.

In actual road practice this heater has taken out about 60 per cent of the dissolved oxygen, and it is known that in stationary boiler practice the oxygen content must be reduced to about 0.5 c.c. per litre to prevent pitting. But the cases are not comparable. In a closed system, like a water

pipe, where there is no surging nor possibility of the escape of oxygen, the extraction must be almost perfect to prevent pitting. In a stationary boiler, where there is steam-space and considerable bubbling of the water, something like 90 per cent of the oxygen must be excluded to prevent pitting. But in a locomotive, where the boiling is many times faster than in a stationary boiler, with violent bubbling and continuous surging, it is certain that a much less complete exclusion of oxygen will be sufficient.

There are some 2000 to 3000 of these open feedwater heaters in use on locomotives, and only a very few of them have reported such prevention of pitting as noted above, but it should be remembered that (1) the water in the heaters is heated only by exhaust steam from the cylinders, and when standing at stations, water, if needed, must be taken through the injector or taken cold through the heater, in either case taking oxygen with it into the boiler; (2) in drifting very little steam is being used, but the heater pump is sometimes kept working so that cold oxygen-charged water goes to the boiler; (3) in hill climbing, it frequently happens that the heater cannot keep up the water supply and the injector is used also; (4) cold water from the engine tank to the heater and hot water from the heater to the boiler are handled by two pumps in the heater, one working against very low pressure, the other against boiler pressure, and if the packing in the hot-water high-pressure pump is allowed to deteriorate, it may easily happen that the low-pressure pump delivers the more water, with the flooding of the heater, cutting off the escape of gases and possibly flooding the enginer cylinders.

Such details of operation and maintenance I explained to our men when the heater was put in service, and they have operated it with almost no trouble.

In this particular water we have proved that pitting can be prevented by keeping intact the film of hydrogen which naturally covers the metal; and the chief advantage of this method of pitting-prevention over other methods is that the prevention costs nothing, while the heater is saving $2000 per engine per year in coal.

PREVENTION OF PITTING AND CORROSION BY ELECTRO-CHEMICAL POLARIZATION

By L. O. Gunderson, Chemical Engineer, Chicago & Alton Railroad

For the past three years the Electro-Chemical Polarization System of pitting and corrosion prevention installed on locomotives on the Chicago & Alton Railroad has successfully prevented all pitting and grooving or other forms of corrosion on flues, fire-boxes and shells of all boilers so equipped. This road has now twenty-three such installations with others under way in the shops for protection of the boiler materials in corrosive water districts. The ease and simplicity with which the system is installed in the boilers and the negligible maintenance and attention required, commend it for railroad service.

The Electro-Chemical Polarization System of protection as installed and successfully operated on the Chicago & Alton Railroad is described essentially as follows: Two perfectly insulated electrodes are inserted in the boiler shell, one in the upper part of the boiler and one diagonally opposite in the lower part. The conducting members of these electrodes are rigidly connected to iron anodes which extend longitudinally practically the entire length of the boiler submerged in the boiler water, and which anodes are rigidly attached by insulated clamps to the boiler shell. Conduited insulated wires connect the electrodes to a shunt from the headlight turbo-generator, with suitable fuses and resistance in series to provide approximately 2 volts with two or three amperes to each electrode, making .001 to .002 ampere per square foot of protected surface. The negative pole of the generator is grounded to the boiler shell, which permits the current to travel in the circuit from anodes through the boiler water electrolyte, and through the boiler metal back to the negative pole of the generator. A soluble arsenic salt is added to the boiler water at the rate of two pounds for initial charge and one pound every two weeks while locomotive is in service. This permits the plating out of the arsenic "secondary cathode," which is the one important essential of the polarization effect which makes the system successful.

It has developed that a reverse electric current alone does not stop local galvanic action or pitting under boiler conditions. It has been demonstrated experimentally in the laboratory (Railway Review, September 24, 1926) and by experience in practical engineering application that the fact that a metallic body acts as a whole as a cathode in an electric circuit does not necessarily stop local galvanic couples from functioning at any point or points on its surface. The experiment mentioned may be duplicated by anyone by simply connecting together a strip of copper and a strip of iron and partly immersing this couple in a dilute acid solution or corrosive water, noting the rapid corrosion of the iron. Now cause this couple to act as a cathode (electro-negative) in an electric circuit by connecting the negative pole of a dry cell to the iron-copper couple and immersing a carbon or other insoluble anode in the same solution or water connected to the positive pole of the cell. It will be found that the corrosion will still continue at only a slightly slower rate. Add a few crystals of sodium arsenate to the solution and all corrosion and local galvanic action will at once cease. This explains the effectiveness of the electro-chemical method in overcoming corrosion.

The mechanism of corrosion in form of pits is somewhat as follows: a small area of the boiler material becomes electro-negative or cathodic in relation to the adjacent area which becomes electro-positive or anodic, which difference of potential causes the anodic area to corrode or pass into solution into the boiler water in contact with it and at the same time hydrogen is plated out of solution onto the cathodic area. This action will continue as long as the difference of potential is strong enough to plate out more hydrogen and evolve it as a gas, and if it is not great enough to evolve hydrogen as a gas then the action will stop almost immediately,

unless there is oxygen in the boiler water. When oxygen is present, as it is in all boiler waters, then it will unite with hydrogen and form water, and the corroding of the anodic area will proceed as fast as this hydrogen is removed, which permits more iron to go into solution. Since an applied electric current alone, plating out hydrogen on the boiler metal, is not able to stop local galvanic action or pitting, it appears that the potential necessary to discharge hydrogen upon the cathodic areas (probably magnetic scale) is lower than the electromotive force which actually exists between the elements of the pits, that is, between the anode and cathode of the local pits. With high hydrogen-ion concentration some corrosion will continue even in the absence of oxygen, and an electric current passed from anodes to the boiler metal as cathode will not succeed in stopping the corrosion, for the tiny galvancic cells within the pits can still continue active, dissolve iron and plate out hydrogen, which are the essential steps in the corrosion reaction according to the generally accepted electrolytic theory. If arsenic is added to the boiler water under the above conditions, it will at once begin to plate out in preference to hydrogen, due to its low discharge potential, but after it is once plated out on the cathodic areas of the pits even in molecular thickness it will prohibit any further plating out of hydrogen by the galvanic cells due to the high discharge potential of hydrogen upon arsenic. In other words the pits will be effectually polarized; and the excess hydrogen plated out by the electric current will prevent oxygen from depolarizing the pits. Thus the protection is complete.

In practical operation the system needs little attention aside from inspection at terminal engine houses by electricians to see that the wiring to electrodes is intact. The interior surfaces of the boiler are uniformly covered with a thin deposit of carbonate scale and silica, giving the flues a very smooth appearance. That this coating does not render any physical protection against corrosion was demonstrated when one of the electrode-equipped locomotives was stored for a period of three months, after which time it was inspected again and rust spots covered the flue, showing that the iron was corroding through the carbonate deposits; the boiler was stored without water, but no efforts were made to dry the interior prior to storage. The special insulation used stands up under boiler conditions remarkably well, which is a guarantee of its continued efficiency.

Through close observation it appears that in at least some water conditions a high hydrogen-ion concentration is developed within the boiler in spite of the high caustic alkalinity of the feed-water introduced into the boiler, and the discharge potential of hydrogen on the cathode of the pits becomes such that under standard conditions of boiler pressure and temperature that hydrogen is evolved as a gas, thus precluding the necessity of depolarization by oxygen, wherein oxygen would enter only as a accelerating agent by facilitating the removal of the hydrogen and decreasing the resistance to the flow of current. This theory would make the hydrogen-ion concentration of the boiler water under boiler conditions the sole criterion of its corrosibility, with oxygen content its factor of acceleration. This condition is overcome by the electric current in conjunction with the polarizing chemical, arsenic.

Appendix D

(4) SODIUM ALUMINATE AS AN AID TO WATER SOFTENING

C. H. Koyl, Chairman, Sub-Committee; C. M. Bardwell, R. C. Bardwell, W. M. Barr, O. W. Carrick, R. W. Chorley, R. E. Coughlan, J. H. Davidson, B. W. DeGeer, L. E. Elliott, E. M. Grime, J. P. Hanley, J. R. Hickox, P. M. LaBach, O. T. Rees, H. H. Richardson, D. A. Steel, Dennistoun Wood.

Some four or five years ago there was offered a new commercial article, sodium aluminate, for use in boilers. Presented first in liquid form as an anti-scale boiler compound it met with indifferent success, but worked up later into a dry powder and offered as an aid to the lime-soda process of water softening it has won its way.

In the plain lime-soda process, the magnesia in the water appears finally as magnesium hydrate, which is a very light precipitate and slow to settle. In difficult cases it has been the custom to add to the treatment from one to three grains-per-gallon of aluminum sulphate or ferrous sulphate so that the aluminum hydrate or ferrous hydrate formed in the reactions should weigh down the light particles of magnesium hydrate and cause them to settle more quickly. It has been found also that this addition of aluminum or ferrous sulphate has acted to free the softened water from the grain or so of calcium or magnesium carbonate which is slow to come out of solution in the settling tank and has caused endless trouble as "after-precipitation," which means coming out of solution later and forming scale in the pipe lines.

When sodium aluminate is used for this purpose instead of ferrous or aluminum sulphate, it is usually found that the results are both more speedy and more complete, and at last a plausible explanation has appeared in the statement that the alumina and the magnesia combine chemically to form the precipitate magnesium-aluminate which is heavy and settles quickly, and the reaction is so complete that it frees the water from the cause of "after-precipitation." About 1½ grains of sodium aluminate per gallon of water is used, and if there is not enough magnesia left in the water to satisfy the alumina then the balance of the alumina combines with calcium to form calcium aluminate.

The composition of the dry sodium aluminate is given as:

Sodium Aluminate ($Na_2Al_2O_4$) soluble in water	76 per cent
Sodium Carbonate (Na_2CO_3)	5 per cent
Water-insoluble	19 per cent

When sodium aluminate is proposed as a substitute for aluminum sulphate as a coagulant in water, the argument is that each pound of aluminum sulphate requires for its proper precipitation .53 lb. of soda-ash and .42 lb. of hydrated lime, and that with aluminum sulphate at 1.30 cents per lb., soda-ash at 1.45 cents per lb., and hydrated lime at 0.55 cent, the actual cost of using a pound of aluminum sulphate is 2.3 cents, and that even so we

get only 17 per cent of the pound of aluminum sulphate available as alumina which is the useful part. On the other hand, we get from a pound of sodium aluminate 48 per cent of alumina, and this without the use of any additional lime or soda-ash. If then enough aluminum sulphate is used to produce 48 per cent of a pound of alumina the cost is 6.5 cents against a sodium aluminate cost of 4.7 cents; and the result of using the aluminum sulphate is to get aluminum hydrate which acts mechanically to weight down the particles of magnesium hydrate which it touches, while the action of the alumina from sodium aluminate is to combine chemically with the magnesia and both make a heavier precipitate and a more complete cleaning up of the magnesia.

In the use of sodium aluminate it is particularly recommended that the powder be not added to the water until after the lime has been added and thoroughly stirred in. The chemical reaction has not yet been solved, but in many waters the addition of the sodium aluminate with the hydrated lime has seriously detracted from the efficiency of the softening. Evidently there is considerable yet to learn concerning the action of this material in the lime-soda softening process.

Feeding of the dry sodium aluminate independently of the lime and soda-ash has in ground-operated plants presented a serious problem. But of late the problem appears to have been solved by feeding the powder in a uniform stream to a small blower which sends it through a pipe to the top of the mixing tank where it is wet by a spray and conducted to the water which has already been mixed with lime and soda-ash. Not the least interesting part of this apparatus is the appliance for feeding the powder from the hopper. The material packs so tightly in the conical hopper that only a column of about three inches diameter (the size of the small end of the hopper) would feed down, while the balance remained behind the vertical wall of this hollow cylinder. Some genius filled the hopper with tin cones, each three inches at the top and all delivering to the common three-inch bottom, and now no one could desire a more uniform feed.

As illustrating the results in railroad water softeners, the report of Paul M. LaBach, of the Rock Island Lines, is selected from the material contributed by members of the Sub-Committee, and follows.

USE OF SODIUM ALUMINATE ON THE ROCK ISLAND LINES

By Paul M. LaBach, Engineer Water Service

The Rock Island Lines began the treatment of water in 1904 by the erection of four lime and soda-ash treating plants of the intermittent type. Since that time there has been a gradual growth until the present year.

At present the following are in operation:

Lime and Soda-Ash Plants	58
Soda-Ash Plants	20
Sodium Aluminate Plants	25
Sedimentation Plants	2

Experience scattered over this period of years showed that something in addition to lime and soda-ash was desirable, particularly in cold weather.

Much of the water in the territory traversed has natural foaming qualities due to sodium salts. Various chemicals, such as alum and iron sulphate, were used without marked success. At points the natural water will cause pitting, corrosion, leaking and foaming.

The use of sodium aluminate, as a third chemical, was begun a couple of years ago in conjunction with lime and soda-ash in different types of softeners. Very careful tests were made with several chemists present in order to ascertain how to use it to the best advantage. Experience has been of great value in anticipating requirements. Separate tests were made for each plant as there was no rule of general applicability apparent at first, although this has been worked out since for a great many places.

In all the following data, direct burette readings are used without subtraction for a lather factor. In a continuous plant at Sheffield, Illinois, the following results were had: Water from creek.

	"H"	*"A"*	*"C"*	*Grs. per Gal.*
River Water	29.0	15.5	...	....
Lime and Soda-Ash	3.5	7.0	4.5	....
Lime, Soda-Ash and Sodium Aluminate	1.0	5.0	2.7	....

In an intermittent plant at Herington, Kansas, water is taken from a creek carrying the sewage for a town of 5,000. The hardness runs about 27.0 and the alkalinity about 22.0. I have no analysis of the raw water the day the following complete analysis was made, but it shows results that are possible:

Date	*Grs. per Gal.*
Calcium Carbonate	0.93
Calcium Chloride	....
Magnesium Carbonate	0.62
Magnesium Chloride	....
Calcium Sulphate	....
Magnesium Sulphate	....
Oxides of Iron, Aluminum and Silicon	0.44
Alkali Chloride	10.09
Alkali Sulphate	27.22
Alkali Carbonate	4.85
Total Solids	44.15
Incrusting Solids	1.99

Tests of the above nature were made at practically all points and treatment adjusted accordingly.

The whole subject was then handled as a routine operation with the treating plant attendant making the daily tests and reporting them weekly on blank forms for the purpose.

The standard to which we work is H-1.5, A-6.5, and C-4.5. As an example of routine performance, the following will illustrate. Averages are used.

WHITEWATER, KANSAS

January, February, March, 1927

Lime, Soda-Ash and Sodium Aluminate:

	"H"	*"A"*	*"C"*
Raw	69.2	14.7	...
Treated	2.1	9.8	6.1

For further illustrations of routine operating results see Table 1, which is compiled averages from routine attendant's reports.

TABLE I—ADDITIONAL SAVINGS ACCRUING FROM THE USE OF SODIUM ALUMINATE IN LIME AND SODA PLANTS

Station	Treated H	Raw H	Lbs. Lime	Lbs. Soda Ash	Aluminate Lbs.	M. Gal. Water	Lbs. Scale Removed	Cost Chemicals	Addl. cost Aluminate	Sav. @ 13c per lb.	Net Saving	Sav. due to aluminate	Same per year
Burr Oak	3.6	30.5	180,200	184,855	66,260	89,183	342,460	$5,936.00	$1,120.00	$45,200.00	$39,264.00	$3,538.00	$ 7,076.00
	5.9	30.5	196,202	227,080		89,183	312,140	4,816.00		40,578.00	35,726.00		
Morris	2.0	13.5	56,500	16,575	16,050	38,444	61,895	1,285.00	495.00	8,046.00	6,761.00	1,204.00	2,408.00
	4.0	13.5	63,000	20,055		38,444	48,824	790.00		6,347.00	5,557.00		
Ottawa	2.5	21.5	64,600	26,600	20,833	47,031	127,454	1,697.26	622.36	16,569.02	14,871.76	1,395.37	2,790.74
	4.8	21.5	76,000	29,800		47,031	111,933	1,074.90		14,551.29	13,476.39		
Bureau	1.9	21.0	98,280	30,490	24,600	58,554	168,050	2,165.98	531.58	21,846.50	19,680.52	4,568.58	9,137.16
	5.5	21.0	116,700	45,507		58,554	128,818	1,634.40		16,746.34	15,111.94		
Sheffield	1.1	28.5	32,027	19,890	11,262	19,540	76,401	979.21	224.60	9,932.13	8,952.92	1,147.16	2,753.16
	4.9	28.5	37,860	29,333		19,540	65,849	754.61		8,560.37	7,805.76	5 months	
Peoria	1.7	16.1	45,634	25,503	12,840	28,525	58,761	1,232.80	246.20	7,638.90	6,406.10	2,784.47	5,568.94
	7.4	16.1	53,200	36,430		28,525	35,371	986.60		4,598.23	3,611.63		
Geneseo	2.4	21.5	25,800	8,200	5,810	16,688	45,558	547.61	123.55	5,922.50	5,374.89	874.05	1,748.10
	5.6	21.5	29,900	12,000		16,688	37,881	424.06		4,924.50	4,500.84		
V. Jct.	2.7	19.0	131,160	52,510	41,571	86,343	201,180	3,338.30	1,193.10	26,153.40	22,815.10	3,072.46	6,144.92
	5.3	19.0	150,834	65,637		86,343	168,368	2,145.20		21,887.44	19,742.64		
Co. Bluffs	1.4	16.5	64,129	45,643	22,935	32,934	71,137	2,013.00	600.00	9,248.00	7,235.00	1,798.00	3,596.00
	5.3	16.5	73,100	57,963		32,934	52,964	1,413.00		5,850.00	5,437.00		
W. Liberty	2.1	19.2	23,591	6,605	6,151	12,429	30,364	517.44	171.58	3,947.32	3,429.88	641.04	1,282.08
	5.6	19.2	24,110	9,934		12,429	24,113	345.86		3,134.70	2,788.84		
Kellogg	2.0	17.0	15,699	7,155	4,700	8,762	18,750	401.00	118.00	2,437.00	2,036.00	212.00	424.00
	4.0	17.0	18,044	8,944		8,762	16,209	283.00		2,107.00	1,8[illegible]4.00		
Manly	2.7	20.5	154,275	7,000	19,502	43,725	110,615	2,055.20	470.05	14,379.95	12,374.75	1,454.55	2,909.10
	5.0	20.5	179,375	10,500		43,725	96,195	1,585.15		12,505.35	10,920.20		
Cedar Rapids	2.4	16.0	85,335	32,915	21,266	49,857	96,722	1,940.20	554.90	12,574.00	10,633.80	2,621.10	5,242.20
	5.8	16.0	101,520	40,080		49,857	72,292	1,385.30		9,398.00	8,012.70		
Estherville	3.0	25.3	22,880	23,436	7,415	14,512	46,438	784.35	135.65	6,036.90	5,252.55	713.25	1,426.50
	6.0	25.3	25,383	31,169		14,512	39,908	648.70		5,188.00	4,539.30		
Fairbury	2.2	11.4	47,000	7,017	13,571	30,892	41,592	978.40	402.00	5,406.90	4,428.50	587.40	1,174.80
	3.4	11.4	56,000	8,981		30,892	33,981	576.40		4,417.50	3,841.10		
Limon	1.9	25.0	62,409	48,790	19,030	20,554	67,828	1,951.40	454.25	8,817.64	6,866.24	881.75	1,763.50
	5.5	25.0	69,400	65,870		20,554	57,551	1,497.15		7,481.64	5,984.49		
TOTAL					313,166	597,973			$7,462.82			$27,493.18	$55,445.20

Comparisons are made on a six-months basis.
Average quantity of sodium aluminate per M. gal.....523 Lb.
Average cost of sodium aluminate per M. gal.....$.019
Average reduction in hardness due to sodium aluminate 2.9 G.P.G.

Per cent reduction in lime per M. gal.....12.7%
Per cent reduction in soda ash per M. gal.....20.9%
Column—"Additional Cost of Aluminate."
This represents cost of aluminate minus saving on lime and soda.

Average results shown are taken from attendant's report for the last six months of 1925 and compared with the same period in 1926.

Following the name of each station are two lines. The top line shows results for lime, soda-ash and sodium aluminate. The bottom line shows average results for lime and soda-ash alone.

The physical results are quite as apparent as the chemical, particularly when the water is 40 deg. Fahr. or less. The lessened amount of sludge in pipe lines resulted in $1,000 per year saving in one terminal. Also old incrustation is gradually coming out of cold water lines.

The advantages gained by the use of sodium aluminate are:

1. Increased plant capacity or output due to more rapid clarification or settling;

2. Less total hardness without the necessity of carrying excess alkalinity and causticity which should, in turn, result in reduced trouble from foaming;

3. The avoidance of the increase of alkali sulphates in treated water resulting from the use of either alum or copperas;

4. The elimination or material reduction in the amount of after-precipitation which will result in:

(a) Reduced trouble of pipe lines, heaters, branch pipes and injectors becoming clogged;

(b) A material reduction in foaming troubles;

(c) A decided reduction in the number of boiler washings.

On one of our operating districts of 4,000 miles (approximately) the engine failures reported were as follows:

	Leaking Failures	*Foaming Failures*	*Total*
1916	89	45	134
1926	2	1	3

This is due to more careful supervision and better water treatment.

The Rock Island uses dry sodium aluminate in intermittent type softeners.

The analysis is as follows:

Sodium Aluminate ($Ma_2Al_2O_4$)	82 per cent
Sodium Carbonate Na_2CO_3	6.5 per cent
Water-Insol.	10.8 per cent

One hundred per cent passes ⅛-inch screen.

In continuous type softeners No. 2 Sodium Aluminate, a liquid, is used. This is put into the downtake about one-third of the distance below the top by a small proportioning pump. The analysis is as follows:

Al_2O_4	20.4 per cent
$Na_2Al_2O_4$	32.8 per cent
Excess NaOH	14.6 per cent
Na_2Co_3	0.0 per cent
Total Na_2O	23.6 per cent

In Table 1 the items of chief importance are, the reduction of hardness, the reduction in the use of soda-ash and lime. By the expenditure of $7,462, a saving in hardness removed of $55,445 in these sixteen plants was made.

Appendix D-1

(4) FOAMING OF LOCOMOTIVE BOILERS, WITH SPECIAL REFERENCE TO THE INFLUENCE OF SUSPENDED MATTER ON FOAMING, AND COST OF BLOWDOWN

C. H. Koyl, Chairman, Sub-Committee; C. M. Bardwell, R. C. Bardwell, W. M. Barr, O. W. Carrick, R. W. Chorley, R. E. Coughlan, J. H. Davidson, B. W. DeGeer, L. E. Elliott, E. M. Grime, J. P. Hanley, J. R. Hickox, P. M. LaBach, O. T. Rees, H. H. Richardson, D. A. Steel, Dennistoun Wood.

In any effort to eliminate trouble, the logical course is first to determine the cause. Among boilermen the word "foaming" does not necessarily imply a true foam anywhere in the boiler but means any condition which produces wet steam; so that our problem is to determine the cause of foaming in locomotive boilers and also the other causes of wet steam.

For long years our discussions on foaming were limited to the statement on one side that foaming is caused by concentration of sodium salts in the boiler, and the statement on the other side that foaming is caused by the small particles of solid matter in suspension in the water in the boiler. Gradually it came to be admitted by each side that the other was partly right, but the question still remained whether sodium salt in solution or solid particles in suspension were the originating cause, since in either case the other was certainly an aggravant.

We all have known that steam rises through the boiler water in bubbles which in good boiler waters break their containing films at the water surface so as to deliver to the steam-pipe steam containing not over 5 per cent of water. And we have known too that if a substance like soap is added to the water, the water skins which surround the steam bubbles become viscous and do not break easily and carry large amounts of water into the steam pipe. On the surface of the water the accumulation of these bubbles is called foam.

Of late years there has been some scientific study of foams with the discovery that a sufficiently stabilized film (tough skin) can be formed when water containing sodium salts in solution also contains in suspension such finely divided solid matter as precipitated sludge, comminuted scale, light mud, etc. So that in a boiler we may expect to find a true foam and its effect of wet steam even without the presence of soap or organic slimes if only the water contains both concentrated sodium salts in solution and fine solid particles in suspension.

As far back as 1919 the Sub-Committee on Revision of our Manual stated, page 280, "Foaming is due primarily to the presence of suspended matter in the water. The suspended matter gives a mechanical strength or tenacity to the liquid in the thin films encasing the steam bubbles, which, rising to the surface, retain their films and collect to produce foam. It is aggravated by the concentration of alkali salts present in the natural waters

or added by the process of water softening, which increases the viscosity of the surface films."

In Professor W. D. Bancroft's book on "Applied Colloid Chemistry," published in 1921, page 268, etc., appears this statement of essentials in foam formation: "To get a foam the only essential is that there shall be a distinct surface film, in other words, that the concentration in the surface layer shall differ perceptibly from that in the mass of the liquid. To get a fairly permanent foam the surface film must either be sufficiently viscous in itself or be stabilized in some way. This can be done by introducing a solid powder into the interface. The presence of enough of a finely divided solid in the interface will make the film so viscous that the foam will be quite stable."

In November, 1924, there appeared in *Industrial and Engineering Chemistry,* Vol. 16, No. 11, page 1121, a paper by Professor C. W. Foulk, of Ohio State University, which brought together all the information to date and gave the results of a long set of laboratory tests to settle disputed points and furnish the foundation for a theory of boiler foaming. He cites various published papers back as far as 1890, each stating the author's inability to get strong alkali solutions foaming except in the presence of matter in suspension, then his own experiments in the laboratory with water boiling in 500-cc. glass flasks at pressures ranging from below that of the atmosphere to 37 pounds per square inch above.

In Professor Foulk's tests, when solutions of various individual sodium salts and various mixtures of these salts were boiled, there was practically no sign of foaming even though the concentrations varied from 25 parts per million to almost saturation. The same results were obtained when other soluble substances were used instead of the sodium salts.

When distilled water was boiled and various powdered substances, such as boiler scale, precipitated calcium carbonate, pumice, boneblack, and limestone, were added, no foaming resulted unless the amount of solids was very large.

But when one of these powders was added to a solution of any of the soluble salts stronger than 500 parts per million, and itself in quantity greater than 500 parts per million, there was, on boiling, immediate formation at the top of the water of a true foam whose thickness increased with increasing strength of the solution or increase of amount of powder, sometimes to two or three inches.

The conclusion from Professor Foulk's flask tests is that foaming commences when sodium salts in solution and finely divided solid matter in suspension each amounts to 500 parts per million or 30 grains per gallon; that increase in foaming follows increase in amount of either soluble or insoluble material up to a maximum at 7000 parts per million or 400 grains per gallon. He finds powders more efficient the finer they are.

Professor Foulk points out that the solid particles must have a natural tendency to adhere to that kind of water if they are to be efficient in stabilizing the films which surround the steam bubbles; and he surmises that the

pronounced efficiency of castor oil in stopping and preventing foaming is due to its reduction of the adherence between particle and water.

Accepting the above as a statement of the causes of boiler foaming with which all can agree, it yet remains for us to learn the upper and lower limits of sodium salt concentration which can be carried with each amount of sludge of a certain character in a locomotive boiler of a certain size, the locomotive doing a certain amount of work and with other operating conditions definitely stated.

Small stationary boilers have been known to carry water containing 3000 to 4000 grains-per-gallon of sodium salts without foaming when the amount of loose sludge does not exceed 10 grains-per-gallon. Road locomotives can seldom carry more than 400 grains-per-gallon, and switch engines can seldom exceed 200 grains-per-gallon. These differences we attribute to the motion of the locomotive boilers and to the fluctuations in the use of steam.

We have found a road engine foaming because the fire was poor and the engine was calling for more steam than the boiler was making. We changed the fireman and improved the fire, and the boiler stopped foaming.

We found a boiler fed with soda-ash water foaming and noticed that the suspended matter in the gage glass looked very fine and light. We increased the amount of soda-ash so as to make a quicker and heavier precipitate which tended to remain in the boiler bottom, and the foaming stopped.

We cite these experimental results to show that a formula covering only the amount of sodium salts in the water, or only the amount of sludge, can have but limited application.

It is certain that, for foaming tests, boilers must be divided into three classes: (1) stationary, (2) road locomotives with approximately uniform motion and approximately uniform use of steam, and (3) switch engines with excessive to-and-fro motion and excessive fluctuations in the use of steam.

For stationary boilers there are unpublished reports showing that one boiler could operate at 225 per cent rating with an alkali-salt concentration of 1300 grains-per-gallon when the load was steady, but with only 230 grains when the load was fluctuating. In another boiler under similar conditions the respective concentrations were 630 grains and 220 grains. No mention is made of the amount or kind of matter in suspension in the water of the boilers.

One large manufacturing company turning out food products which must be cooked in dry steam, has made a long and careful determination of permissible conditions as to solid matter in suspension and matter in solution which can be carried in its stationary boilers so as never to have wet steam. The boilers were water tube, from 300 to 800 HP., carrying a steam pressure of 145 lb., and working from 140 to 200 rating, averaging about 160 rating. Its report is that when using such waters as that of Lake Michigan and precipitating the calcium and magnesium salts as sludge within the boiler, not more than 200 grains-per-gallon of alkali salts in solu-

tion can be carried in the boilers; but when using water from an efficient water-softening plant whose effluent water is not more than one grain-per-gallon hard, the boiler water can carry 600 to 800 grains-per-gallon of alkali salts; and when using a natural water which contains only a trace of calcium and magnesium, but 87 grains-per-gallon of various kinds of sodium salts, there is no difficulty in operating boilers with a concentration of 2500 grains-per-gallon total solids.

In the matter of boilers in motion, O. W. Carrick, of the Wabash Railway, and other locomotive men who use the method of precipitating the sludge within the boilers by means of soda-ash, have found that the boilers of road engines must be blown off with sufficient frequency to prevent the alkali concentration exceeding 250 parts-per-100,000, or 150 grains-per-gallon. Mr. Carrick states that determination of the foaming point was made by observation of the whistle, the pop-valves, and the lubrication of the cylinders; the engines were carrying water as low as possible in the glass, were developing their maximum boiler power, but were not subject to fluctuation of steam demand. The feedwater was free from sewage and low in organic matter, and no anti-foam compound was used.

Using waters which had been treated with soda-ash so that the scale matter would be precipitated within the boiler he found that when the feedwater was clear as it entered the boiler an alkali concentration of 175 grains-per-gallon could be carried without foaming; when the feedwater was slightly turbid the highest concentration was 145 gr.p.g. and with feedwater very turbid only 125 gr.p.g. With clear feedwater less than 10 gr.p.g. hard (so that there would be little precipitation within the boiler) he found the permissible concentration mounting finally to 500 gr.p.g. Chart marked "A" shows the results graphically. Chart "B" illustrated a method used on the Wabash for instructing enginemen as to amount of water to be blown off; and chart "C" gives the results of a road test using the waters shown on "B." The purpose of the test was to demonstrate the ffectiveness of blowing off to prevent foaming and to indicate that the locomotive could be operated indefinitely so far as foaming was concerned without water change or washout. Charts "D," "E" and "F" illustrate conditions of waters from locomotive boilers on the Chicago & Alton Railroad where feedwaters are similarly treated with soda-ash.

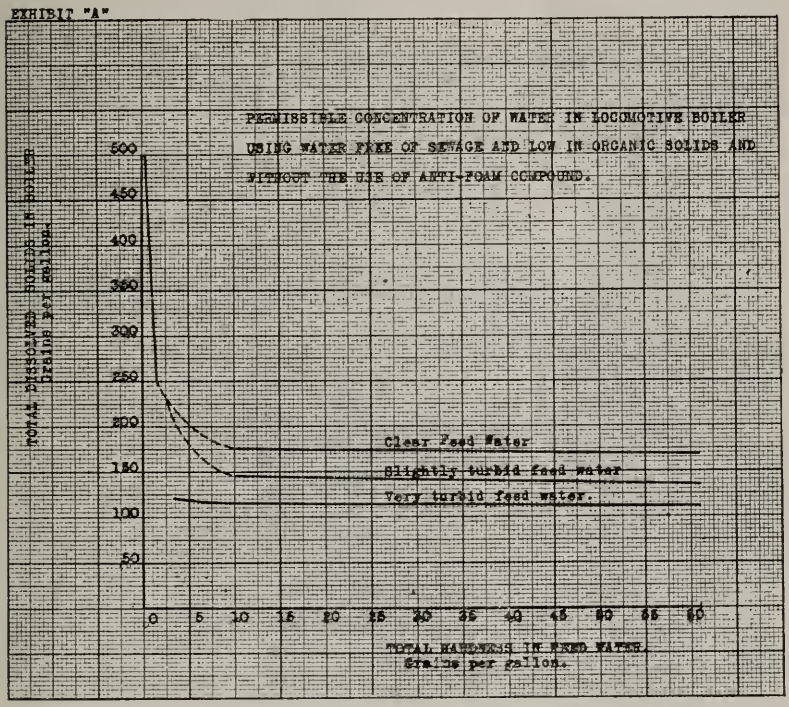


Exhibit B

LOCOMOTIVE BOILER WATER ANALYSES SHOWING AMOUNT TO BE BLOWN OFF PER 1000 GALLONS EVAPORATED TO PREVENT FOAMING

Water Station	Untreated Water		Lbs. Soda Ash Required per 1000 Gal.	Alkali Salts Treated Water	Per Cent Water to Blow	Gals. to Blow per 1000 Evap.
	Total Hardness	Sulphate Hardness				
Decatur.....	10.6	5.6	.80	14.3	5.7	57.0
Lanesville.....	32.0	3.0	.50	13.6	5.4	54.0
Riverton.....	27.2	5.2	.68	16.4	6.6	66.0
Springfield.....	13.6	5.6	.70	20.6	8.2	82.0
Jacksonville.....	22.8	4.8	.60	14.8	6.8	68.0
Bluffs.....	46.6	15.6	1.5	30.8	12.3	123.0
Valley City.....	22.6	5.1	.66	12.6	5.0	50.0
Maysville.....	24.4	10.4	1.1	19.0	7.6	76.0
Kinderhook.....	12.5	5.5	.50	16.7	6.7	67.0
Hannibal.....	24.0	7.0	.83	15.0	6.0	60.0

Based on permissible concentration of 250 parts per 100,000 of alkali salts in locomotive boiler.

Exhibit C

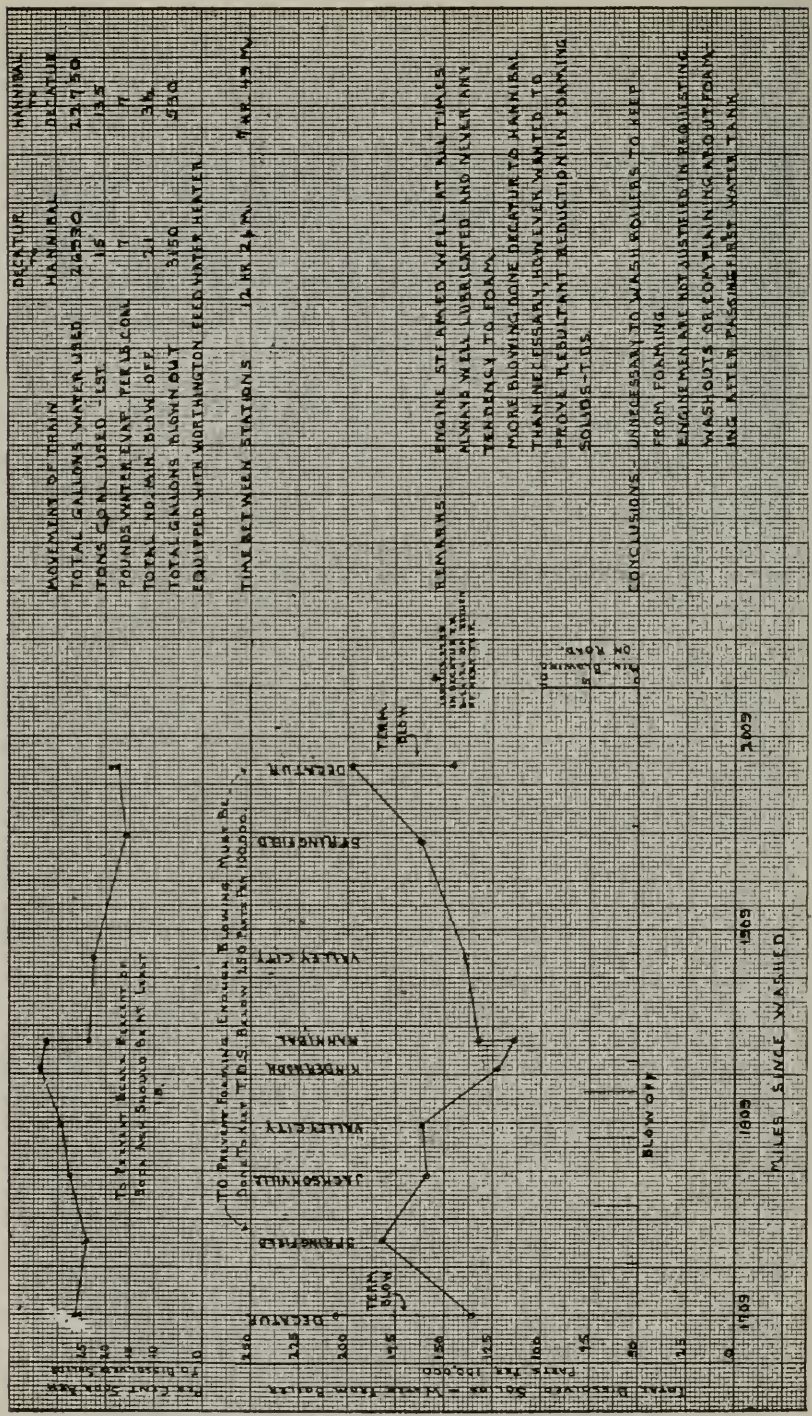

MOVEMENT OF TRAIN
DECATUR TO HANNIBAL
HANNIBAL TO DECATUR
TOTAL GALLONS WATER USED
26930
22750
TONS COAL USED - EST.
15
135
POUNDS WATER EVAP. PER LB. COAL
7
7
TOTAL NO. MIN. BLOW OFF
21
36
TOTAL GALLONS BLOWN OUT
3150
530
EQUIPPED WITH WORTHINGTON FEED WATER HEATER
TIME BETWEEN STATIONS
12 HR 24 M.
7 HR 49 M.
REMARKS - ENGINE STEAMED WELL AT ALL TIMES ALWAYS WELL LUBRICATED AND NEVER ANY TENDENCY TO FOAM.
MORE BLOWING DONE DECATUR TO HANNIBAL THAN NECESSARY, HOWEVER WANTED TO PROVE RESULTANT REDUCTION IN FOAMING SOLIDS - T.D.S.
CONCLUSIONS - UNNECESSARY TO WASH BOILERS TO KEEP FROM FOAMING
ENGINEMEN ARE NOT JUSTIFIED IN REQUESTING WASHOUTS OR COMPLAINING ABOUT FOAMING AFTER PASSING FIRST WATER TANK.
TO PREVENT SCALE PERCENT OF SODA ASH SHOULD BE AT LEAST 15.
TO PREVENT FOAMING ENOUGH BLOWING MUST BE DONE TO KEEP T.D.S. BELOW 250 PARTS PER 100,000.
DECATUR
SPRINGFIELD
JACKSONVILLE
VALLEY CITY
KINDERHOOK
HANNIBAL
VALLEY CITY
SPRINGFIELD
DECATUR
TERM. BLOW
TERM. BLOW
BLOW OFF
MIN. BLOWING ON ROAD
MILES SINCE WASHED
1709
1809
1909
2009
Per Cent Soda Ash To Dissolve Solids
Total Dissolved Solids - Water From Boiler Parts Per 100,000

Exhibit D

LOCOMOTIVE BOILER WATER ANALYSIS

(Expressed in Parts per 100,000)

Samples Collected at Chicago & Alton Railroad

Date Collected	Eng. No.	From	Dissolved Solids	Total Hardness	Alkalinity Methyl Orange	Percent Sodium Carb. T. D. S.	Phenol phthalein	Causticity OH
8-22-27.....	804	Roodhse. Slater	308.0	0.5	108.0	35.0	82.0	56.0
8-22-27.....	822	"	275.8	0.5	105.0	38.0	80.0	55.0
9-14-27.....	812	Slater to Roodhse.	401.4	0.5	115.0	28.6	73.0	31.0
9-14-27.....	886	"	283.3	0.5	101.0	35.5	54.0	7.0
4-4-27.....	627	Slater to K. C.	294.8	0.8	54.0	18.3	33.0	12.0
5-13-27.....	Switcher 44	Bloom.	411.0	0.5	54.0	13.1	40.0	26.0
9-9-27.....	Switcher 62	"	300.4	0.8	30.0	9.98	15.0	0.0
9-9-27.....	Switcher 412	"	465.2	0.5	67.0	14.4	45.0	23.0
8-15-27.....	Switcher 65	Bloom.	298.6	0.8	38.0	12.7	25.0	12.0

NOTE.—The above represent maximum values under which locomotives were operated without sign of foaming, with good lubrication.

REMARKS.—To prevent scale formation and leaking flues, water should show 15 per cent sodium carbonate to total dissolved solids.

To prevent foaming, enough blowing should be done to keep total dissolved solids below 250 parts per 100,000. Carrying the water too near the foaming point reduces the efficiency of the locomotive, due to wet steam and and impaired lubrication.

Exhibit E

LOCOMOTIVE BOILER WATER ANALYSIS

(Expressed in Parts per 100,000)

Samples Collected at Chicago & Alton Railroad

Date Collected	Eng. No.	From	Dissolved Solids	Total Hardness	Alkalinity Methyl Orange	Percent Sodium Carb. T. D. S.	Phenol phthalein	Causticity OH
2-22-27.....	Stat.	Slater	2749.2	0.5	554.0	20.1	428.0	302.0
1-6-27.....	"	"	1416.2	0.5	62.0	4.37	41.0	20.0
4-1-27.....	"	"	1036.2	0.5	172.0	16.6	136.0	100.0
6-20-27.....	"	Bloomington	626.0	0.5	185.0	29.5	122.0	59.0
7-12-27.....	"	"	523.0	0.5	255.0	48.7	158.0	61.0
7-14-27.....	"	"	481.2	0.5	218.0	45.3	142.0	66.0
10-7-26.....	Sw. 338	Dwight	621.0	8.0	12.0	0.07	6.0	0.0
4-4-27.....	Sw. 321	"	574.4	6.0	6.4	0.0	0.0	0.0
7-20-27.....	Sw. 321	"	772.2	4.5	8.0	0.4	4.5	1.0
10-8-26.....	Sw. 409	Glenn	127.2	0.8	58.0	45.5	42.0	24.0
4-5-27.....	Sw. 394	"	86.8	0.9	39.0	44.9	34.0	29.0

(Above are maximum values.)

REMARKS.—To prevent scale formation and leaking flues, water should show 15 per cent sodium carbonate to total dissolved solids.

To prevent foaming, enough blowing should be done to keep total dissolved solids below 250 parts per 100,000. Carrying the water too near the foaming point reduces the efficiency of the locomotive, due to wet steam and impaired lubrication.

NOTE.—Yard engines at Dwight use untreated deep well water, which runs approximately 95 to 100 parts per 100,000 alkali salts, 30 parts total hardness, 1 or 2 parts sulphate hardness.

Glenn yard engines use sewage polluted canal water.

Exhibit F

LOCOMOTIVE BOILER WATER ANALYSIS

(Expressed in Parts per 100,000)

Samples Collected at Chicago & Alton Railroad

Date Collected	Eng. No.	From	Dissolved Solids	Total Hardness	Alkalinity Methyl Orange	Percent Sodium Carb. T. D. S.	Phenolphthalein	Causticity OH
12-15-26.....	623	At Chicago	267.2	0.8	28.0	10.5	19.0	10.0
12-15-26.....	623	At Bloom.	318.4	0.8	39.0	12.2	22.0	5.0
12-29-26.....	653	Bloom. to Chgo.	322.2	0.8	108.0	33.5	80.0	52.0
4-3-27.....	634	"	275.6	0.5	102.0	37.0	73.0	44.0
7-21-27.....	602	"	311.0	0.5	94.0	30.2	72.0	50.0
7-21-27.....	399	Chicago	275.8	0.5	144.0	52.2	124.0	104.0
9-16-27.....	842	Bloom. to Chgo.	330.6	0.5	78.0	23.5	54.0	30.0
3-9-27.....	879	Bloom. to Venice	295.4	0.5	68.0	23.0	50.0	32.0
4-3-27.....	840	"	289.6	0.8	89.0	30.7	65.0	51.0
4-3-27.....	888	"	292.4	0.5	93.0	31.8	69.0	45.0
4-7-27.....	300	Peoria to Dwight	287.0	0.5	72.0	25.1	55.0	38.0
7-19-27.....	103	Francis Rdhse.	328.8	0.5	54.0	16.4	30.0	6.0
8-23 27.....	607	Francis Slater	305.8	0.5	66.0	21.5	42.0	18.0

REMARKS.—To prevent scale formation and leaking flues, water should show 15 per cent sodium carbonate to total dissolved solids.

To prevent foaming, enough blowing should be done to keep total dissolved solids below 250 parts per 100,000. Carrying the water too near the foaming point reduces the efficiency of the locomotive, due to wet steam and impaired lubrication.

Cost of Blowdown

We offer a mathematical demonstration, prepared by R. A. Tanner, with formulæ and charted curves illustrating the cost of blowdown where the blowdown point has been determined. You will note that it is based on steam consumption and not on the total amount of water fed to the boiler as in our previous chart on page 207 of Bulletin No. 281 of 1925.

COST OF BLOWDOWN OF LOCOMOTIVE BOILERS

By R. A. Tanner, Assistant Engineer, Northern Pacific Railway.

When water containing ordinary impurities is used in a boiler, some of the water will be utilized as steam while the solids remain. As new feedwater is added, more and more solids will accumulate in the boiler and a part of these solids, depending on the character of the water, will precipitate and form sludge or scale. When the sludge and dissolved solids reach a certain concentration, it becomes necessary to "blowdown" the boiler to prevent foaming. This concentration may be called the "Blowdown Point" and practically it becomes identical with the "Foaming Point" of alkaline waters.

As new feedwater is added to replace the blowdown water, the concentration will be slightly below the blowdown point, gradually increasing as steam is exhausted and additional feedwater admitted, until it again becomes necessary to blowdown the boiler.

The blowdown point will vary considerably with different waters, load conditions, etc., and may also be influenced by the use of anti-foaming compound, but for this discussion it is sufficient to assume that it lies between 1000 and 15,000 parts per million, i.e., 58.5 and 877.2 grains per gallon.

It may be assumed that the same amount of steam will be exhausted during identical engine runs, and that the feedwater is partly used to maintain the steam supply and partly wasted as blowdown.

In order to determine these relative amounts, let it be assumed that a quantity V of feedwater contains S solids per unit, or a total of VS solids.

If the blowdown point is F, then a quantity $W = V\frac{S}{F}$ ..... (1)

must be blown off, leaving a quantity $V' = V - W$ ..... (2)

which can be utilized as steam.

From (2) we have $V = V' + W$ and, inserting the value of W from (1), we have $V = V' + V\frac{S}{F}$, from which $V = V'\frac{F}{F-S}$, ... (3)

i.e., the quantity of feedwater required, and

$$W = V - V' = \frac{V'F - V'(F-S)}{F-S} = V'\frac{S}{F-S}, \quad \text{..... (4)}$$

i.e., the quantity of feedwater blown off.

These formulæ are well illustrated by considering the two extremities.

If the feedwater contains no impurities, then $S = O$, W becomes O, i.e., no blowdown is required, and V becomes V', i.e., all feedwater is utilized to make steam.

If, however, the feedwater contains as much impurities as the permissible blowdown concentration of the boiler water then $S = F$, V as well as W becomes infinite, i.e., all feedwater must be blown off as soon as it is heated to the steaming point, and V' becomes O, i.e., no steam can be utilized,

The blown off water represents several losses, of which the wasted heat, water and chemicals for treating the water shall be considered.

The heat loss in a gallon of blown off water is 8.34 $(t-t')$ B.T.U., where 8.34 is the pounds of water in a gallon, t is the temperature of the blown off water and t' the temperature of the water as fed to the tender; t is obtained directly from the steam pressure tables, and t' from temperature readings at the standpipes.

If the unit price of fuel is P, and each unit contains B—heat units (B.T.U.), and the efficiency of the boiler is E, then each heat unit cost $\frac{P}{BE}$, and the heat loss in each gallon of blown off water becomes

$$C' = \frac{8.34\,(t-t')\,P}{BE}, \quad \ldots\ldots (5)$$

If C'' is the cost of water, according to the water station records, for each gallon delivered to the tender, including pumping, treating, anti-foaming compound, waste, etc., then the total cost of heat and water is $C' + C''$ per gallon, the cost of blowdown will be $L = W(C' + C'')$,...(6) and by inserting the value of W from (4) we have

$$L = \frac{S}{F-S} V' (C' + C'') \quad \ldots\ldots (7)$$

It is convenient to take $V' = 1000$ and let $C = V'(C' + C'')$.....(8) whereby the cost of blowdown per 1000 gal. water (8340 lb.) actually exhausted as steam becomes $L' = C\frac{S}{F-S}$, ...(9)

Formulæ (3), (4) and (9), using $V' = 1000$, give a direct comparison of the amounts of feedwater, blowdown and cost of blowdown of various waters based upon the identical power output of 8340 lb. steam exhausted.

It may sometimes be practicable to recover part of the heat of the blown-off water for heating the feedwater. This may effect a saving in live steam otherwise used in the feedwater heater, and a corresponding credit should be given to the blowdown cost; or it may raise the temperature of the feedwater, and a higher value should then be given to t' in equation (5).

No credit, however, can be given to the blowdown cost for any heat and water recovered in the boiler-washing plant, as the boiler washing is an additional expense chargeable to the impurities of the water, and the credit should go to the boiler washing plant.

This discussion does not intend to fix any value for the blowdown point F. Pending further development in this field, it will be necessary to depend upon experience, with occasional experiments, to determine the blowdown point for any particular water, or for the mixture of waters usually encountered in the engine run.

The following example illustrates the use of these formulæ in preparing the graph, also how additional cost scales may be applied for frequently recurring values of C, and the use of the graph for quick comparison:

V = gallons of feedwater required per 1000 gal. exhausted as steam.
V' = 1000 gallons of water (8340 lb.) exhausted as steam.
F = 5000 ppm. (292.4 gr.p.g.) blowdown point, selected by experience.
S = 1000 ppm. (58.5 gr.p.g.) solids in the feedwater, by analysis.
P = \$0.0016 per lb. corresponding to \$3.20 per ton of coal.
B = 11,000 B.T.U. per lb. of coal.
E = 0.5, efficiency of boiler.
t = 388 deg. Fahr., temperature boiler water under 250 lb. steam pressure.
t' = 38 deg. Fahr., temperature of water as fed to tender.
C'' = \$0.00015, cost per gallon water in tender, from records.

Then:

From (3), $V = V' \dfrac{F}{F - S} = 1000 \dfrac{5000}{5000 - 1000} = 1250$ gal.

From (4), $W = V' \dfrac{S}{F - S} = 1000 \dfrac{1000}{5000 - 1000} = 250$ gal.

From (5), $C' = \dfrac{8.34\ (t - t')\ P}{BE} = \dfrac{8.34 \times 350 \times 0.0016}{11{,}000 \times 0.5} = \$0.00085$

From (8), $C = V''\ (C' + C'') = 1000\ (0.00085 + 0.00015) = \$1.00$

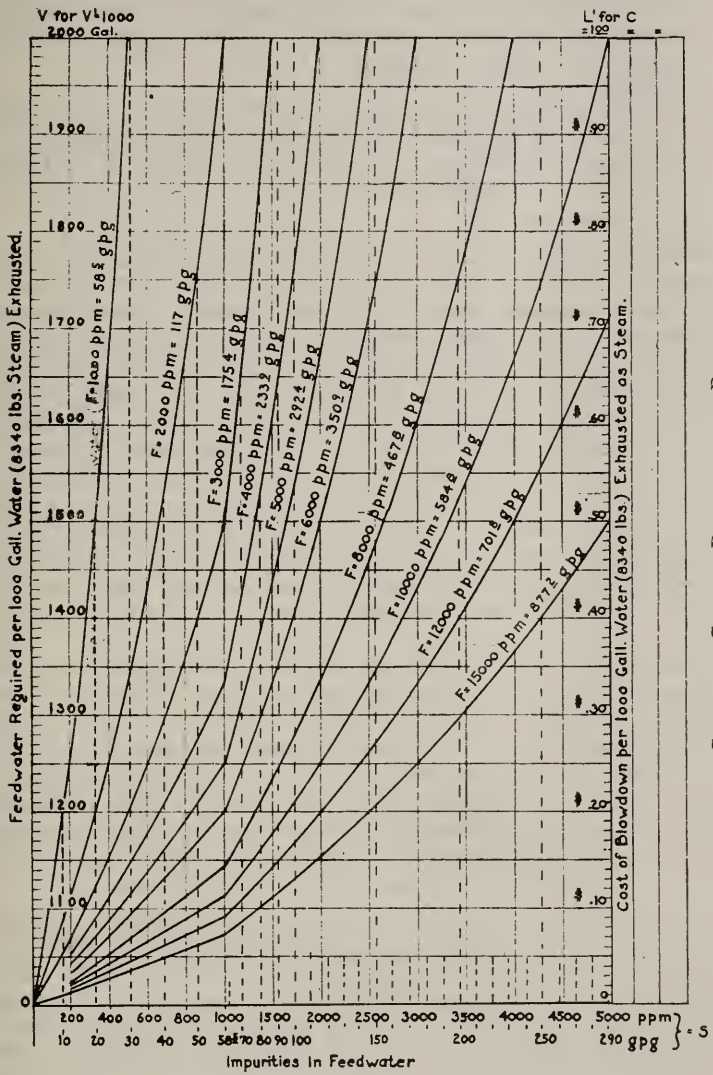
From (9), $L' = C \dfrac{S}{F - S} = 1 \dfrac{1000}{5000 - 1000} = \$0.25$

Start at 1000 ppm. at bottom of graph, follow the vertical line to its intersection with the curve for $F = 5000$, then to the left margin where 1250 gal. is found as the required amount of feedwater; then follow the same line to the right margin where $0.25 is found as the cost of blowdown; all per 1000 gal. water exhausted as steam.

If the blowdown point F had been 3000, then, by following the same vertical line to the intersection with $F = 3000$, the required feedwater would be found at the left margin as 1500 gal., and the cost of blowdown on the same line at the right margin as $0.50, all per 1000 gal. water exhausted as steam.

If the impurities through treatment or supply of better water is reduced to $S = 600$ ppm., and $F = 3000$ as before, then 1250 gal. feedwater is found at the left and $0.25 blowdown cost at the left.

In the graph the impurities in feedwater S are shown in full lines for parts per million, in dotted lines for grains per gal., and the curves for the blowdown points, F, are given in ppm. with corresponding gr.p.g., as F and S must be expressed in the same unit.



Graph of Cost of Blowdown of Boilers

Appendix D-2

(4) CARBONATE AND SULPHATE WATERS, THEIR RELATIVE INFLUENCE ON THE OPERATION AND MAINTENANCE OF BOILERS AND THEIR COMPARATIVE COSTS OF PURIFICATION

C. H. Koyl, Chairman, Sub-Committee; C. M. Bardwell, R. C. Bardwell, W. M. Barr, O. W. Carrick, R. W. Chorley, R. E. Coughlan, J. H. Davidson, B. W. DeGeer, L. E. Elliott, E. M. Grime, J. P. Hanley, J. R. Hickox, P. M. LaBach, O. T. Rees, H. H. Richardson, D. A. Steel, Dennistoun Wood.

Referring again to the classic work of the Water Committee of 1914 in determining the damage done to a boiler per pound of scale deposited in it by heated feedwater—classic, because each successive re-determination, whether made on one engine district or on a whole railway, serves to emphasize the statements that 7 cents of those days, or 13 cents of our day, is a fair measure of the cost of repairs and extra fuel resultant from the average pound of hard scale deposited in a boiler, and that this can be calculated in advance by analyzing the water and determining the amount to be used—referring to this statement, we find it sometimes misunderstood. The formula applies only to the natural hard scale deposited in a boiler from the use of natural hard water. It is accurate when applied to waters only slightly hard and scale which is thin. The result is too low when the formula is used to calculate the damage from very hard waters, and very much too low when applied to scaling waters which also cause boiler leaking.

The formula does not say that carbonate and sulphate scale have dosed with soda-ash or any kind of scale precipitant, so that the incrusting matter is deposited as soft scale within the boiler.

The formula does not say that carbonate and sulphate scale have equal influence on boiler cost, and it is reasonable to suppose that they are not alike though our Committee last year was not able to affirm a difference. But this year we were requested to extend our report to include a statement of the comparative costs of purging carbonate and sulphate scaling matter from water, and R. W. Chorley has written briefly as follows:

"It is often found that boiler waters of equal degrees of hardness differ in the amount of damage which they do to boilers, and analyses of the waters show that in those doing the greater damage the proportion of sulphate to carbonate scale is the greater.

"The cause of the damage to the boilers is principally the insulating property of the scale which restricts the passage of heat from metal to water, causing overheating of the metal which results in warping, fire-cracking and rapid deterioration. Firebox sheets and other heating surfaces of a boiler are limited to definite thickness of metal. The steam pressure on boilers has been greatly increased in the past few years and the shells and other parts which are not heating surfaces have been proportionately increased in thickness, but side sheets and flue sheets and other heating surfaces have not been increased in thickness, the added strength being obtained by increasing the number of staybolts.

"Sulphate incrusting matter is more costly to take from water than carbonate incrusting matter.

"To precipitate in a settling tank and be entirely rid of calcium or magnesium bi-carbonate requires per grain of calcium carbonate only .56 grain of quick lime or .74 grain of hydrated lime, and per grain of magnesium carbonate only .67 grain of quick lime or .88 grain of hydrated lime.

"The sulphates of calcium and magnesium cannot be precipitated and gotten rid of by the lime-soda treatment but can merely be converted into sodium sulphate which does not scale but tends to foam, and the process requires .78 grain of soda-ash per grain of calcium sulphate or .88 grain of soda-ash *and* .88 grain of hydrated lime per grain of magnesium sulphate.

"With hydrated lime, at 0.6 cent per pound and soda-ash at 1.3 cents per pound, the cost of chemicals for treatment becomes:

Per pound calcium carbonate	.44 cents
Per pound magnesium carbonate	.52 cents
Per pound calcium sulphate	1.01 cents
Per pound magnesium sulphate	1.66 cents

"It should be noted that not only is sulphate water the more costly to treat but it is also more costly to use, because of the loss of water and heat due to the blowing-out necessitated by the concentration of sodium sulphate in the water in the boiler. In common practice each pound of dissolved sodium sulphate costs about 4 cents in blowdown water, and each pound of soft sludge and other matter in suspension costs about one cent unless blown out by the necessity for reducing alkali concentration."

Appendix E

(6) TYPES OF HYDRANTS FOR COACH YARDS AND GENERAL SERVICE AND METHODS FOR SUPPLYING WATER TO COACHES

J. H. Davidson, Chairman, Sub-Committee; J. P. Hanley, F. H. Kornfeld, W. B. McCaleb, R. L. Holmes, H. E. Silcox, H. W. VanHovenberg, J. B. Wesley, J. M. Fitzgerald.

GENERAL

For convenience in handling the Sub-Committee has divided this subject into three sections as follows:

1. Hydrants for coach yards and passenger station platforms where coaches are watered.
2. Methods of supplying water to coaches from hydrants, including care and handling of hose, nozzles and connections.
3. Hydrants for general service such as ash pits, stock yards, small stations and similar facilities.

HYDRANTS FOR COACH YARDS AND PASSENGER STATION PLATFORMS WHERE COACHES ARE WATERED

Information received from representative railroads from all sections of the United States, shows that the most satisfactory types of hydrants for this purpose embody the following features:

1. Hydrant should be placed in a pit or box the top of which is flush with platform or surface of ground. This feature removes the hazard of personal injuries presented by high top hydrants and also permits trucking on platforms and in coach yards.
2. Quick opening type of valves should be used and hose connections which permit hose to be equickly attached or removed. The time for watering coaches in transit is usually limited and the saving in time effected by quick opening valves and easily manipulated hose connections is important.
3. Except in localities where freezing weather is never experienced, the hydrants should be self-draining-non-freezing or adequately frost proofed.
4. Adequate drainage should be provided to carry away surface waste as well as water drained from the hydrants. Ground drainage is seldom satisfactory. Pipe drainage is preferred. The proper method will depend on local conditions, the character of soil and frequency of use of hydrants.
5. Hydrants should be so constructed and installed that repairs may be easily and quickly made without the necessity of digging.
6. Construction of valves should be such that they will withstand hard usage and will not require frequent renewals to prevent waste of water.

Hydrants meeting the above requirements are available and are in use by many railroads.

One type of hydrant in general use is assembled by using a stop and waste or similar hydrant valve, suitably installed in a covered pit which provides protection against pollution, mechanical injury to parts of the hydrant, freezing, and also provides drainage. Globe valves and air cocks should not be used in this service as they require constant maintenance and are a source of great waste of water.

The hydrant cock which has a "stop," usually a pin, to indicate when valve is properly closed is a source of considerable water waste due to the fact that the stop pin becomes broken off or lost, allowing the valve to be reversed and permitting water from the main to be wasted, often undetected, especially when waste is connected to pipe drainage systems.

There is a type of hydrant cock on the market which does away with the "stop" and in which the drainage ducts are so arranged that the valve cannot be reversed so as to waste water. Fig. 1 and Fig. 2 show the hydrant cock with broken pin and plug reversed so that water can waste through the drain hole. Fig. 3, 4 and 5 show details of an improved type of hydrant cock which will prevent such undetected waste of water.

Pits provided for hydrant cock installations should be constructed to meet local conditions, due consideration being given to drainage and danger from freezing. Fig. 6, 7 and 8 show details of some typical installations.

Another type of hydrant which has proven satisfactory for this service is one which requires no pit. The valve box is made of castiron with a steel lid which protects the nozzle and is an integral part of the hydrant. It is made for any depth of bury and the inner parts can be easily removed for repairs without any digging. The valve is quick opening, a vertical lift of three-eighths inch opens it wide and unless the handle is placed on a rest provided for this purpose, a spring closes the valve as soon as the handle is released. Thus the valve cannot be left partly open nor can vibration of passing trains accidently open the valve. It is self-draining and non-freezing when placed at proper depth. The top of the box is placed flush with platform or if in earth or cinders is usually placed in a small mound of concrete. The lid is so arranged that it is self-closing and cannot be left open. This removes the hazard of someone stumbling over lid or stepping into the box.

Reports from various railroads using this type of hydrant indicate that they greatly reduce the waste of water as compared with globe valve, cut-out cocks and similar arrangements and that the maintenance costs are very low. Fig. 9, 10 and 11 show details of this hydrant.

Fig. 12 shows details of a recent installation of these hydrants at Alexandria, Louisiana, on the Texas and Pacific and Fig. 13 shows details of installation at Bowling Green, Kentucky, on the Louisville & Nashville.

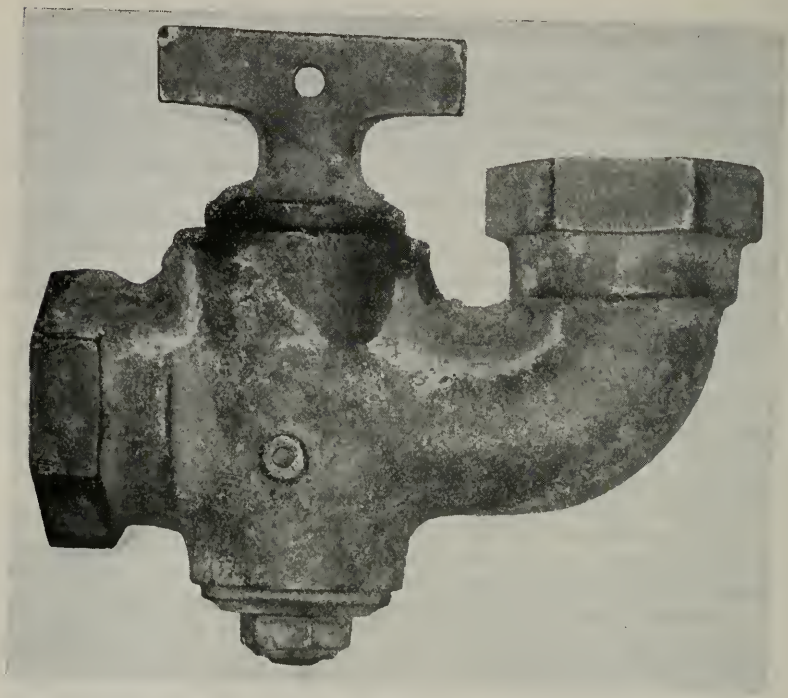


Fig. 1

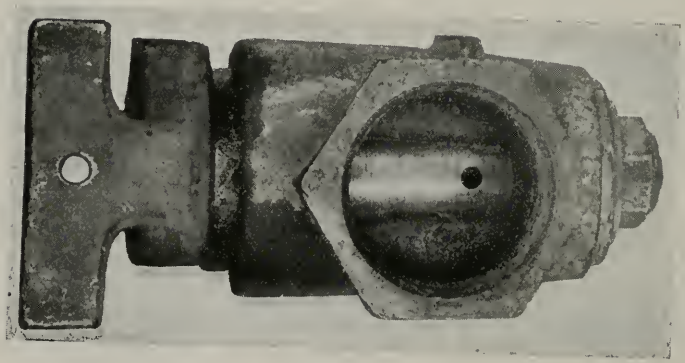


Fig. 2

Unimproved Hydrant Cock

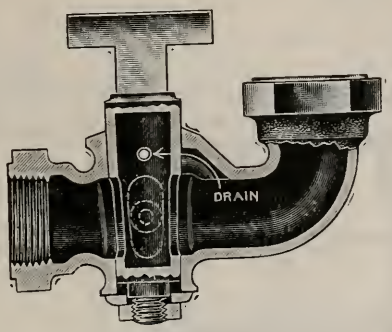


Fig. 3

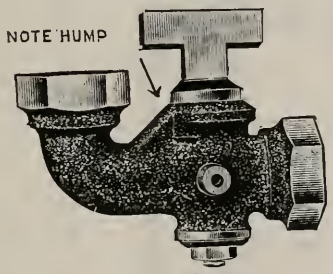


Fig. 4

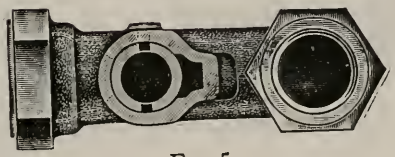


Fig. 5

Improved Hydrant Cock

A

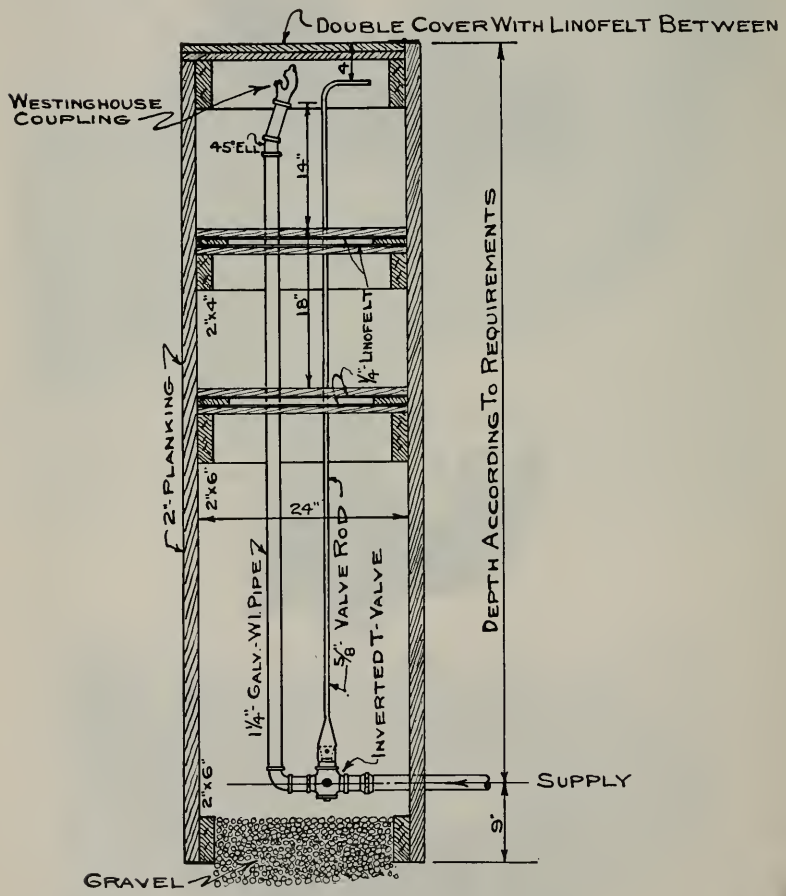
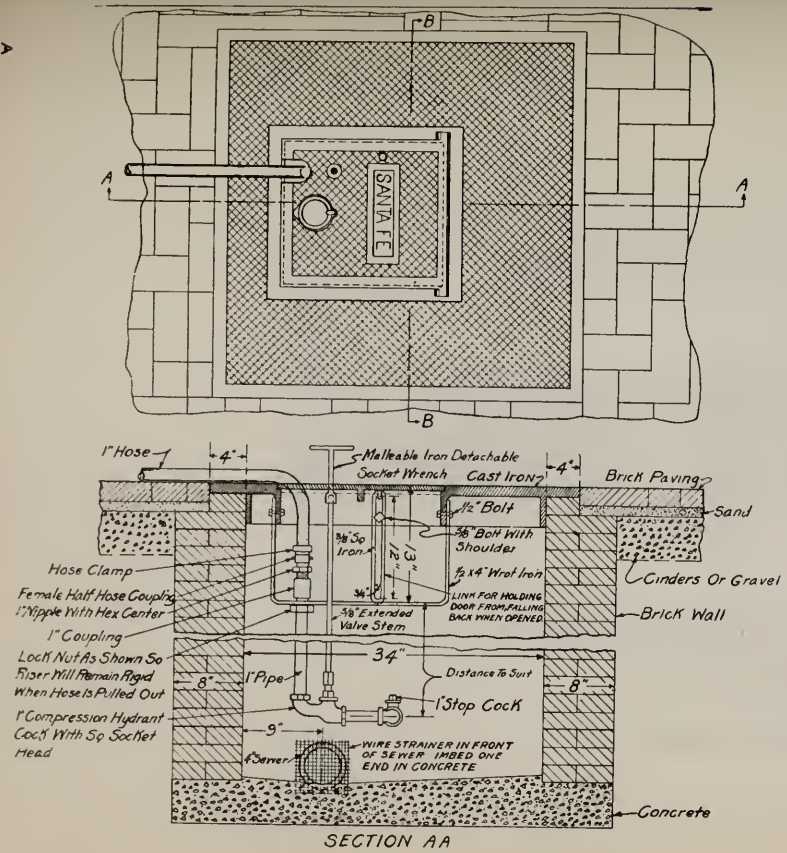


Fig. 6—Hydrant Installation



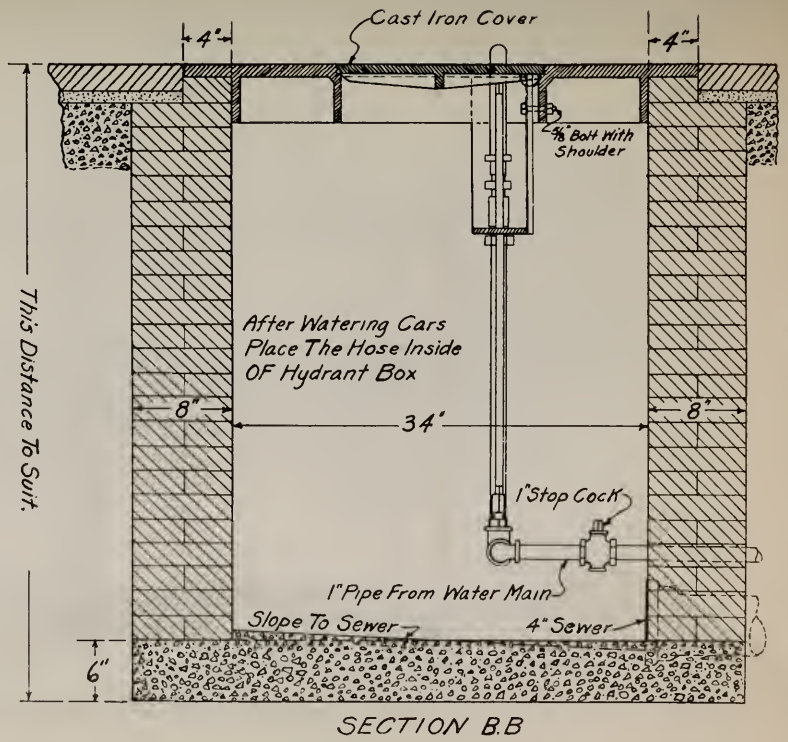


Fig. 7—Special Hydrant Box for Passenger Stations

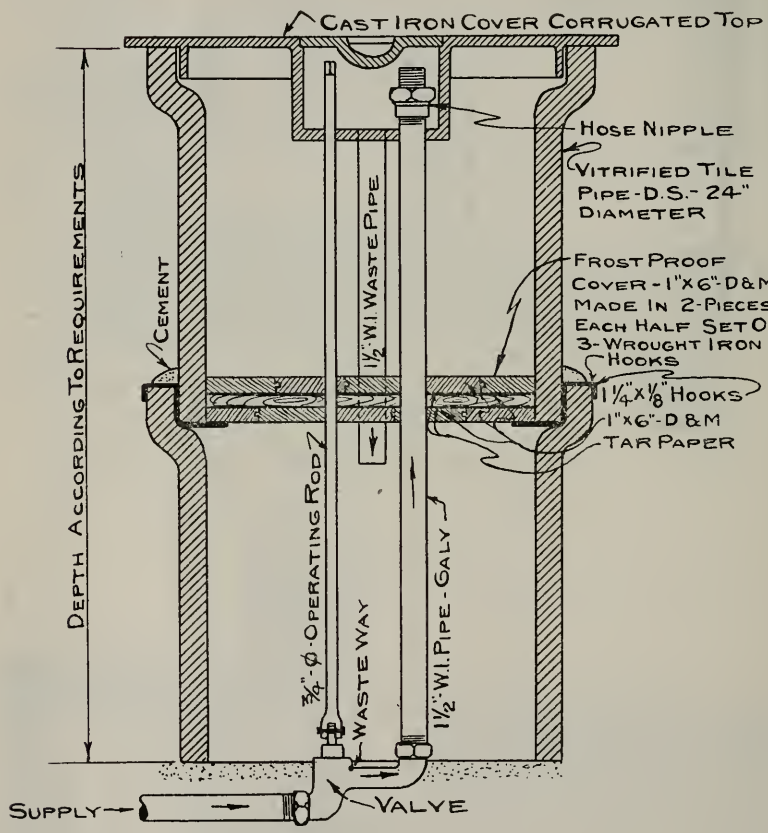


Fig. 8—Hydrant Installation

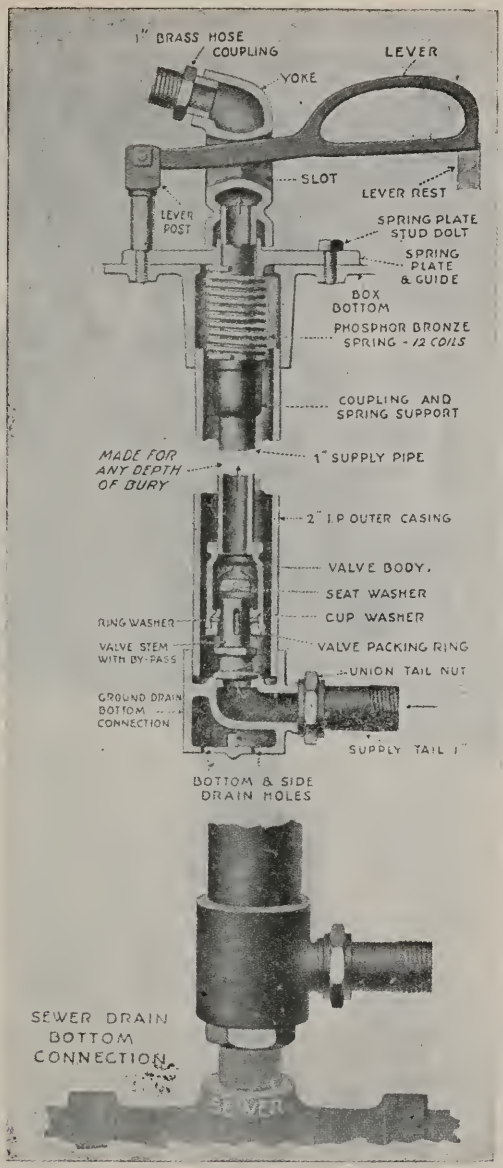


Fig. 9

Quick Opening, Non-Freezing Hydrant

Fig. 10

Quick Opening, Non-Freezing Hydrant

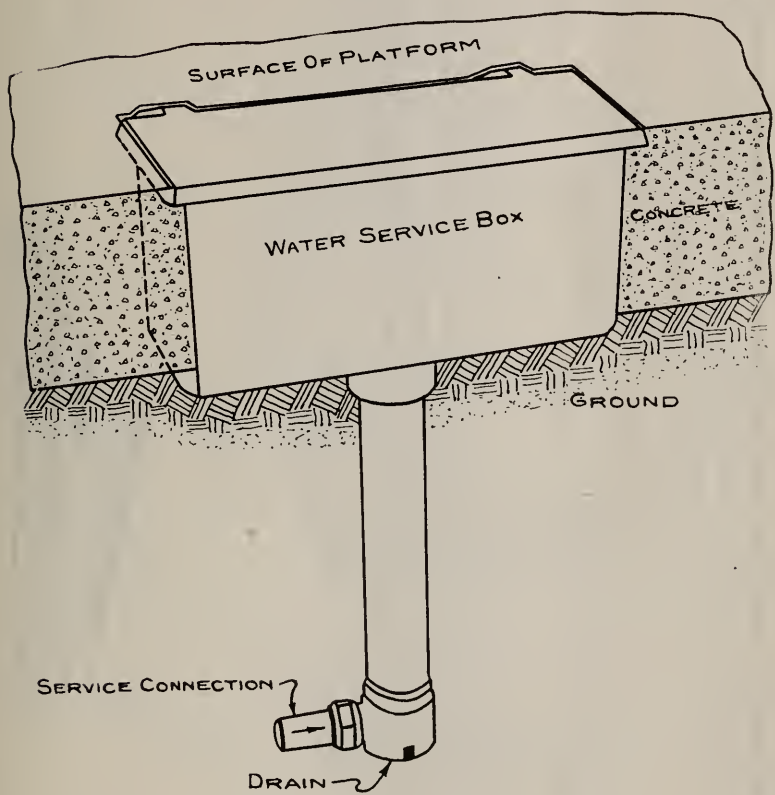
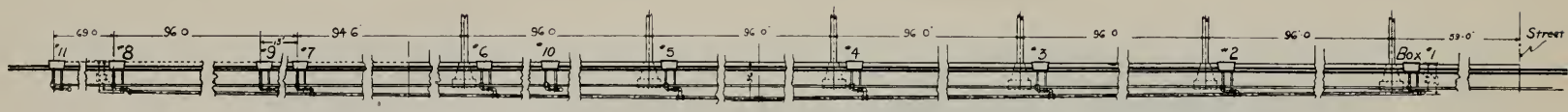
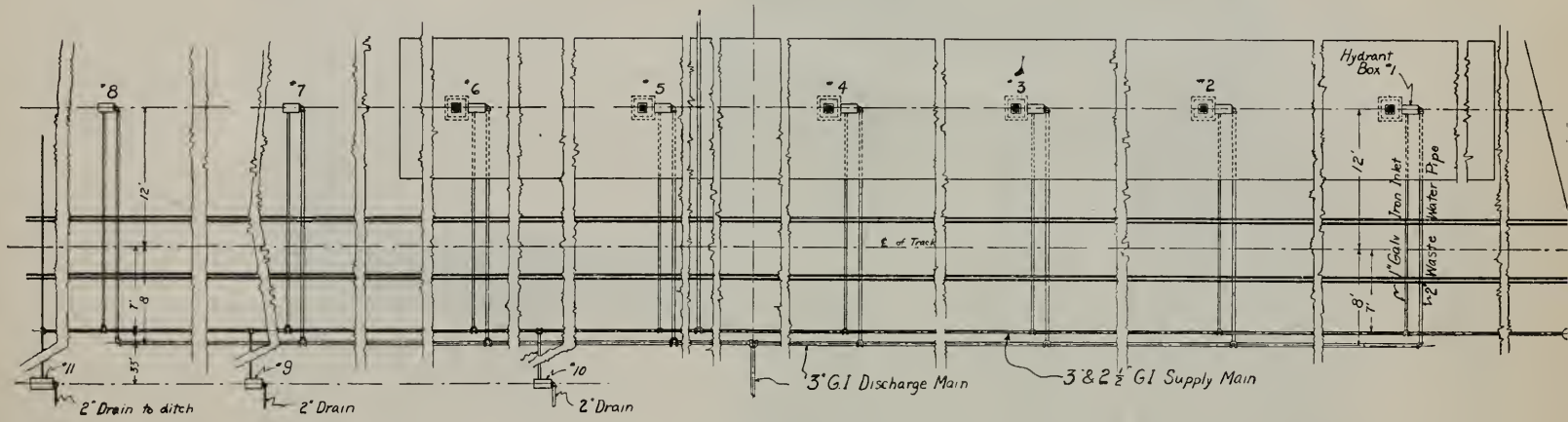


FIG. 11—SHOWING INSTALLATION IN CONCRETE PLATFORM



SECTIONAL VIEW



PIPING LAYOUT

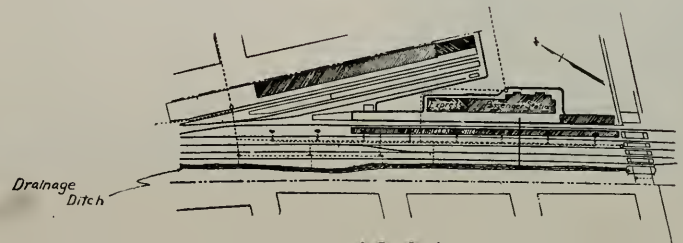


FIG. 12

FIG. 12.—COACH WATERING FACILITIES AT PASSENGER STATION—T. & P. RY.

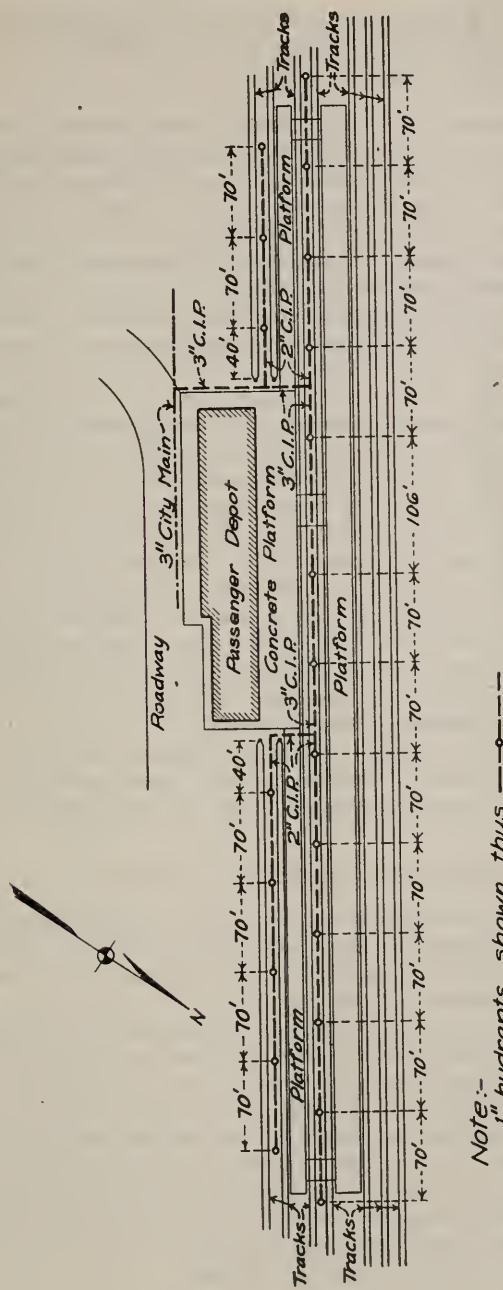


Fig. 13—Coach Watering Facilities at Passenger Station—
L. & N. R. R.

METHODS OF SUPPLYING WATER TO COACHES FROM HYDRANTS INCLUDING CARE AND HANDLING OF HOSE, NOZZLES AND CONNECTIONS.

Although there are a few small terminals where drinking water is carried from hydrants to coaches in buckets, the method generally employed is to convey the water through hose. This method is satisfactory in practically all respects except in regard to danger of pollution of the water. Pollution of drinking water is frequently introduced through dragging the watering hose ends along the ground or platform, by throwing the hose under coaches onto ground or platform, or from top of coaches to the ground. Such handling renders it practically impossible to prevent contamination of the ends of the hose and the water which passes through the hose.

Special nozzles and devices to protect the ends of the hose are in limited use. Their usefulness depends in a large measure on the manner of handling. If used in accordance with instructions, they may be effective in preventing pollution but if used carelessly they are of doubtful value.

One type of nozzle in use at certain terminals of the Illinois Central is described on pages 409-411 of Vol. 22 of the Proceedings of this Association. Another type now being used on the Texas and Pacific is shown in Fig. 14. Fig. 15 shows details of a proposed nozzle protector.

A few roads have tried providing hydrant pits sufficiently large to permit coiling hose in them when hose is not in use. This does not overcome the danger of pollution as the hose is dragged over ground or platform when being taken to or from the hydrant pit. The extra expense of such an installation is not justified by benefits derived.

The Committee recommends that coach watering crews be given instructions in proper use of equipment and that closer supervision be given to the process of watering coaches in order that principles of sanitation be followed.

HYDRANTS FOR GENERAL SERVICE

Both the high top hydrants and those with top flush with the surface of the ground are suitable for cinder pit service, the local conditions governing which type is to be preferred. If there is danger of freezing, they should be of self-draining, non-freezing type.

As a general rule the self-draining, non-freezing, quick opening type placed in a pit or with a self-contained valve box is to be preferred over other types. Satisfactory types are shown in Fig. 6, 8, 16 and 17.

For use at stock yards, some type of high top hydrant is preferred. They should be rugged in construction and have no parts which can be easily damaged or removed. Where there is danger of freezing they should be of the self-draining type. Unless these hydrants are to be placed in a paved area it is not usually considered necessary to place them in pits although repairs can be much easier made if pit is provided. Fig. 16, 17, 18 and 19 show satisfactory types of hydrants for stock pens.

The various types of hydrants described as suitable for ash pits and stock pens can be adapted to general service around stations and grounds.

Conclusions

The most suitable type of hydrant for coach yards and station platforms is a quick opening, self-draining, non-freezing valve in a pit or box flush with the surface. Types which have proved satisfactory are shown in Fig. 6, 7, 8, 9, 10 and 11.

The method of conveying drinking water from hydrants to coaches through hose is satisfactory in practically every respect excepting the very important one of sanitation. No method of protecting nozzles and hose ends yet devised has proven entirely satisfactory since these devices cannot offset the evils of careless handling. Proper instruction and supervision of forces watering coaches will be more effective in promoting sanitation than mechanical devices.

Types of hydrants which have proven satisfactory in general service are shown in Fig. 16, 17, 18 and 19.

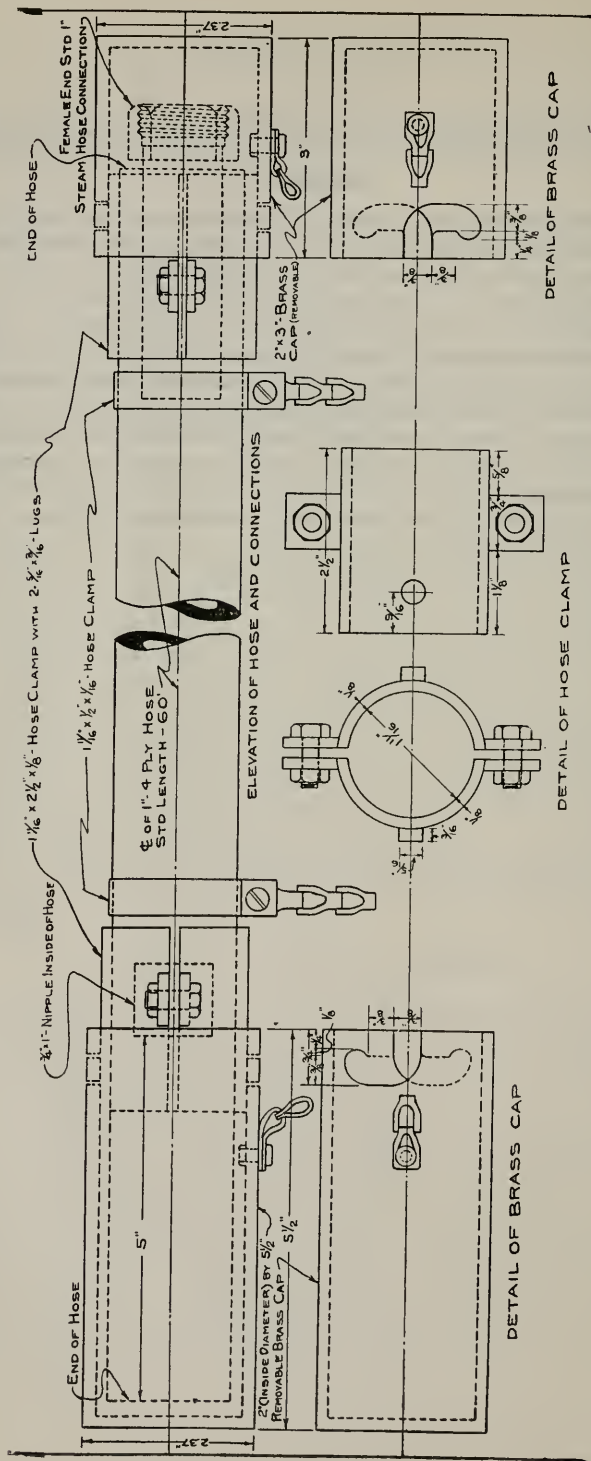


Fig. 14—Hose End Protector

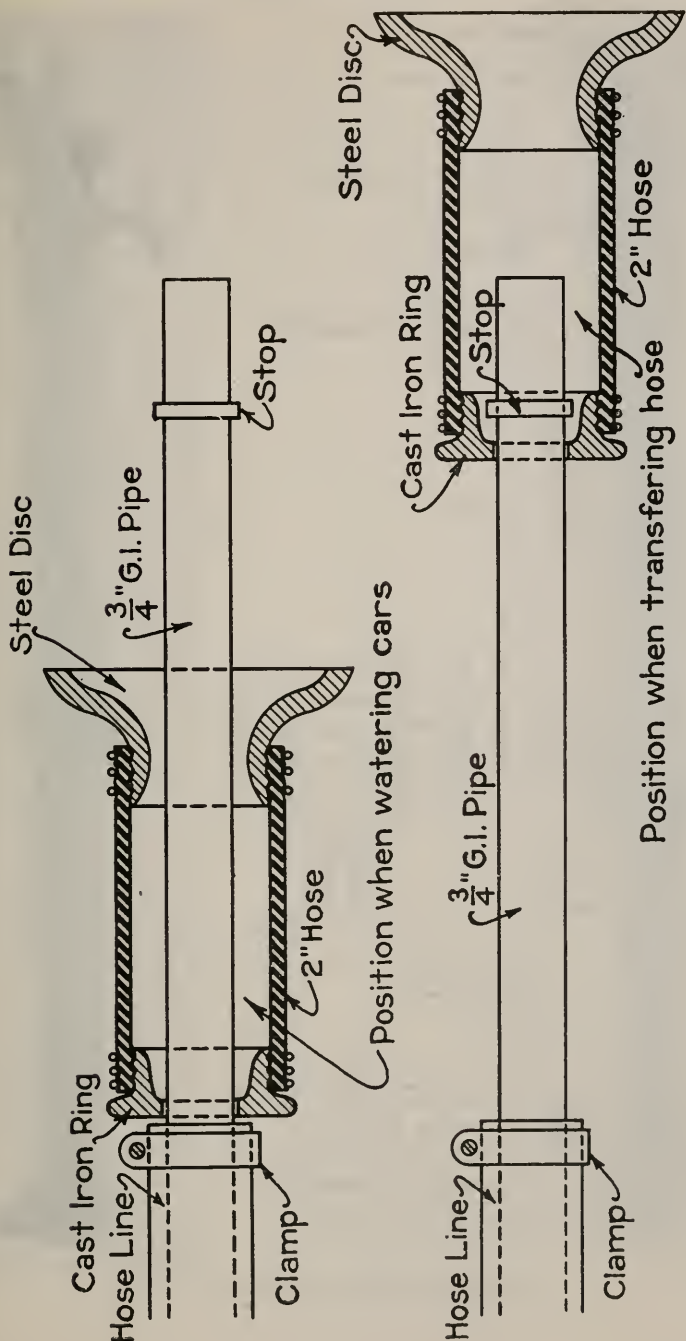
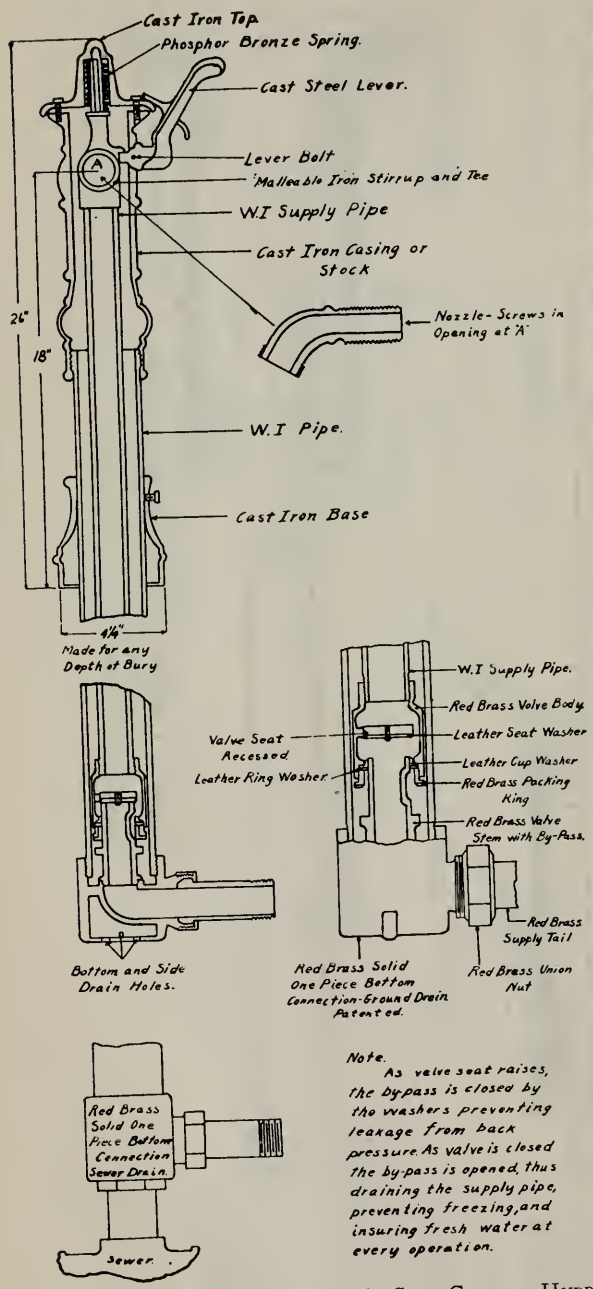


Fig. 15—Proposed Telescope Nozzle Protector



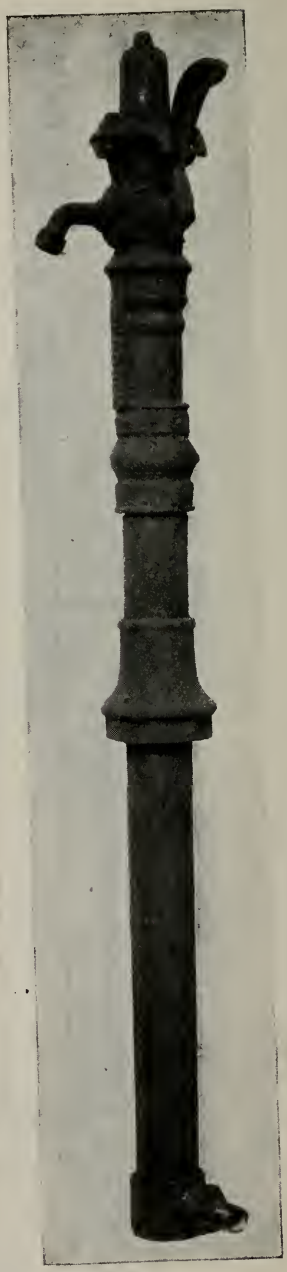


Fig. 16—Self-Closing Hydrant

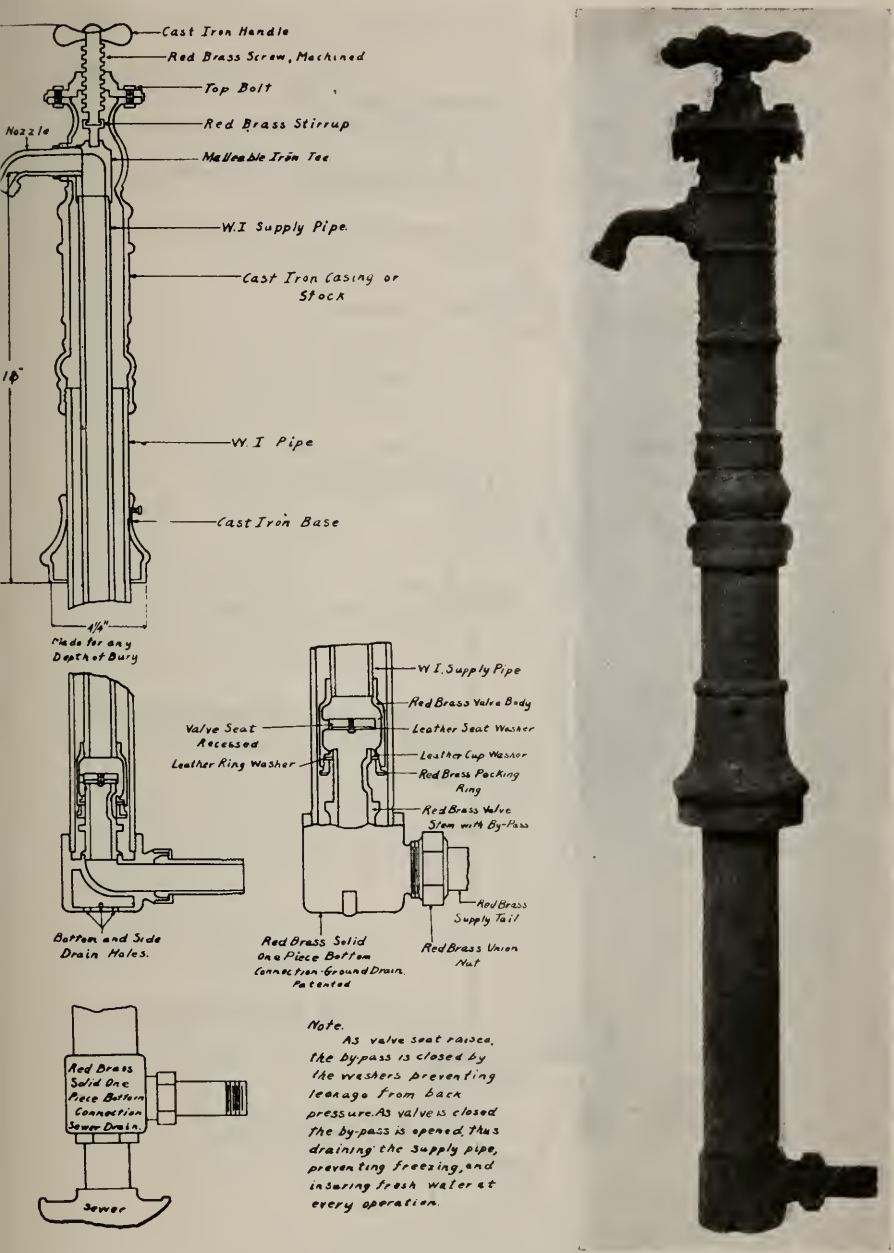


Fig. 17—Detail of Compression Hydrant

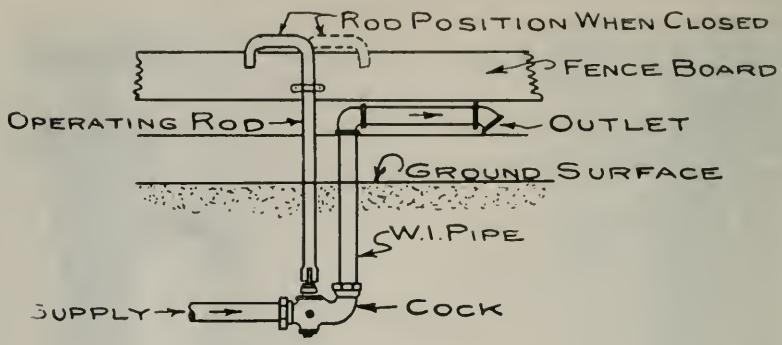


FIG. 18—HYDRANT

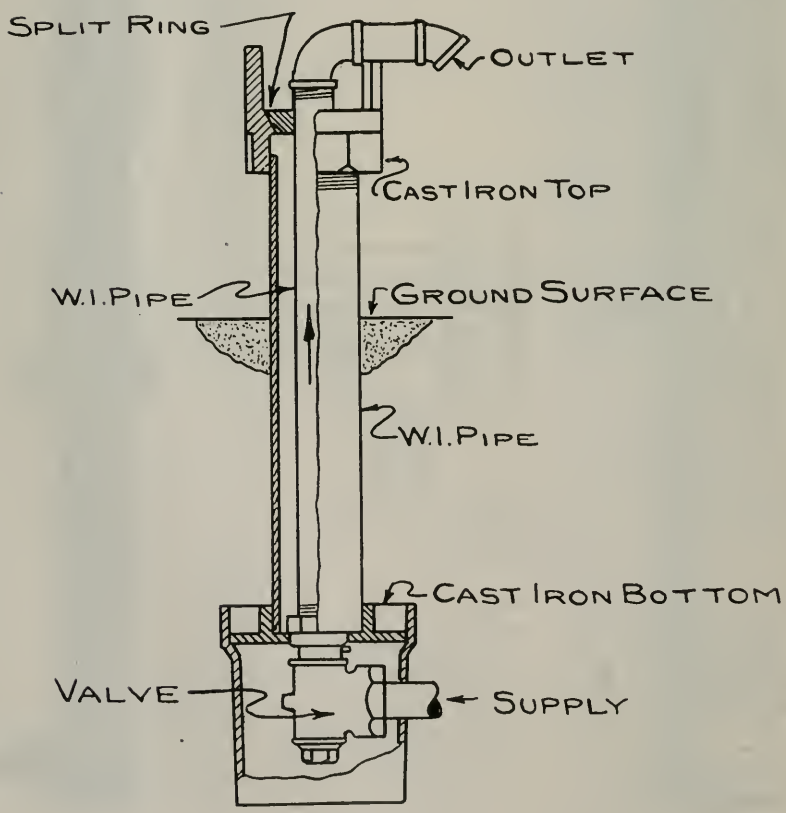


FIG. 19—HYDRANT

Appendix F

(6) PIPE FOR SERVICE LINES, THREE INCHES AND UNDER IN SIZE, WITH PARTICULAR REFERENCE TO THE USE OF PREPARED JOINT CAST IRON PIPE AND COPPER AND BRASS PIPE AS SUBSTITUTES FOR STEEL AND WROUGHT IRON PIPE

J. P. Hanley, Chairman, Sub-Committee; J. M. Fitzgerald, F. H. Kornfeld, H. E. Silcox, A. E. Willahan, F. D. Yeaton.

General

A service pipe is one used in conveying water from the distribution system to a particular building or facility, and the report is intended to cover this class of pipe only.

The cost of installing and maintaining water service pipes in the early days of railway building was relatively smaller than at present. Less interference was encountered from paving, trackage and other surface construction. The smaller amount of underground sewers and drains did not carry off the leakage of defective pipes to such an extent as now exists. Leakage then found its way to the surface more readily and repairs were made more economically than at the present time.

The increased cost of present-day repairs coupled with the growing insistence of water users for uninterrupted service has created conditions which call for the installation of service pipes of very durable materials.

Municipal Practice

The conditions just referred to apply in municipal operation to an even greater extent than in railway practice and municipal water servicemen have studied the service pipe problem for years. We have read many of their reports and have summarized some of the information and conclusions they have worked out, which, we believe, will be of benefit to this Association.

The "Report of the Committee on Service Pipes" of the New England Water Works Association published some years ago contained the following conclusions on service pipe:

1. It should not affect the water passing through it to the injury of the health of the water users.
2. It should not affect the appearance or taste of the water.
3. It should have sufficient capacity to give adequate service at all times.
4. It should be strong and durable.
5. It should be easily laid.
6. It should be inexpensive.

Kinds of Service Pipe

These requirements are not always easy to meet as it is often difficult to select pipe which combines all the qualities necessary to meet varying conditions of soil, water and mechanical stresses.

The following kinds of material are used for service pipe:

Galvanized wrought iron	Copper
Galvanized wrought steel	Brass
Lead	Cast iron

Galvanized Iron and Steel Service Pipe

This class of pipe exceeds all other classes now used for service lines. The galvanizing should be well-done to retard corrosion and prevent discolored water. This pipe has the advantage of being strong and not easily flattened or punctured, and of being easily laid. It has the disadvantage of being less durable than lead or copper pipe and incrusts and corrodes. It will not last long if laid in corrosive soils, and should be used only under favorable soil and water conditions. Under similar conditions wrought iron pipe is generally more durable than wrought steel pipe.

Lead Service Pipe

Lead pipe has been known since the earliest times. Specimens of it have been found in the ruins of the ancient Roman water systems. It is now largely used by cities under pavements where very durable service is required. It has the disadvantage of being easily flattened or punctured and in saline soils, when "wiped" joints are used, has been known to be subject to galvanic action, which weakens the joint. Some waters will dissolve lead to a sufficient extent to cause lead poisoning, but these cases are rare and can be guarded against and should not cause prejudice to this class of service pipe under usual conditions. Lead has so many advantages that it will, perhaps, always be a very acceptable material for service pipes. It does not corrode or incrustate, can be readily bent around obstructions and when properly installed gives no mechanical trouble. It has an indefinitely long life and high salvage value.

Brass Service Pipe

Brass or bronze has been used for ages in the manufacture of utensils and is now used in industry where other metals will not last long under the effects of certain elements; for example, in marine service piping and condenser tubing.

The development in the mining and manufacture of copper has so reduced its cost that the use of pipe made of copper and its alloy, brass, is now coming into commercial competition with galvanized wrought iron and lead pipe for service lines.

Brass is a mixture of copper and zinc in various proportions. There are mixtures which contain 60 per cent copper and 40 per cent zinc; 65 per cent copper and 35 per cent zinc, and 70 per cent copper and 30 per cent zinc. A variation of the latter mixture is 70 per cent copper, 29 per cent zinc and 1 per cent tin and is known as admiralty metal. This metal is

used extensively in marine piping and other work subject to the action of salt or brackish water. Pipe with 85 per cent copper is also manufactured and is sometimes referred to as "red brass" owing to color given by the high copper content.

Brass service pipe is made in the usual wrought iron pipe sizes and may be cut and threaded with standard iron pipe tools. It combines many of the advantages found separately in wrought iron and lead pipe, but not combined in either. It has strong wall construction coupled with extreme durability under service conditions.

Fittings of approximately the same composition as the pipe should be used, as under certain conditions fittings of a different composition might create a tendency to electrolysis at the junction of the pipe and fitting.

Copper Service Pipe

This pipe contains 99 per cent pure copper and is softer and more pliable than brass pipe. It has higher resistance to corrosion than brass but is slightly more expensive and more easily damaged by flattening, puncture or other mechanical means.

The joints of copper service pipe are usually made by expanding and flanging the ends of the pipe in the fittings by means of a special tool. Threading may also be done as in the case of brass or iron pipe, but the ductility of the copper lends itself readily to the flanging process.

Standard Bell and Spigot Cast Iron Service Pipe

This pipe is made in the 2 and 3 inch sizes, the 2-inch size is made in 9-foot sections and the 3-inch size in 12-foot sections, At the present time there is an extra cost of $10 per ton on 3-inch cast-iron pipe as compared with the price quoted on cast iron pipe in sizes 6 inches and over, and the price of 2-inch castiron pipe is quoted on a per-foot basis. This differential is asked by the manufacturers on account of the extra cost of incorporating the metal in pipe of the smaller sizes. It will, no doubt, always exist but might be reduced through the usual economies of greater production if the demand for small cast iron pipe increases.

This class of pipe is usually coated with a tar pitch coating and possesses many advantages for water service. The joint has the disadvantage of being affected by traffic vibration when laid under tracks, which may cause leakage. As recommended by this Committee in their report on Pipe Lines, appearing in Vol. 27, 1926, Proceedings of the Association, we believe that in such installations bell and spigot pipe should be incased or otherwise protected against traffic vibration.

Screwed Joint Cast Iron Service Pipe

This class of pipe is made in 1¼, 2 and 3 inch sizes. The 1¼-inch size is made in 5-foot sections and the 2 and 3 inch sizes in 6-foot sections. It may be used with standard screwed fittings.

Fittings are made for connecting this class of pipe with wrought iron screw pipe and bell and spigot cast iron pipe. The ends of screwed cast iron pipe are prepared for threading by increased wall thickness and the

manufacturers recommend that any adjustments in length be made by cutting the pipe to proper length and using bell end fittings to reconnect it, instead of attempting to cut threads on unprepared sections of the pipe in the field.

Pre-Calked Joint Cast Iron Service Pipe

This class of pipe is made in 1¼, 2 and 3 inch sizes and in sections 5 and 6 feet long. The joint is moulded in the pipe bell at the factory by means of lead, jute and steel wedges. A mandrel slightly larger than the spigot end of the pipe it represents is inserted in the bell around which the joint is poured, and calked for approximately one-half of its perimeter. When the pipe is laid the pre-calked part of the joint should be turned down in the trench and the top section of the joint calked against the pipe which has been inserted. This top calking forces the pipe against the pre-calked bottom section which is also given a light calking for finishing the entire joint. The use of prepared joints eliminates the use of jointing material in the field and permits lower priced labor in pipe installations.

Bolted Joint Cast Iron Service Pipe

This pipe is made in 2 and 3 inch sizes and in sections 6 feet long. It is also known as universal joint cast iron pipe. The joint is made by machining and tapering the ends of the pipe so that they will fit closely when bolted together. This joint should be considered when pipe lines are laid in partially consolidated fills or other locations where settlement may be expected, as it allows considerable variation from established line or grade without straining the pipe joint.

At the present time ordinary steel bolts are furnished with this pipe. It is our opinion that an improvement would result by using genuine wrought iron bolts sherardized or copperized, these bolts to have sufficient oversize to withstand corrosion during the estimated life of the pipe in addition to the mechanical stresses for which the joint is designed.

This pipe is easily laid and does not require the use of calking equipment in the field, it can be laid without excavating bell holes and permits the use of fewer men in pipe installation than bell and spigot pipe of the same size.

Pipe Linings and Coatings

Under special water conditions it is sometimes found advisable to use lined pipe. Linings are usually made of tin, lead or cement. Tin lining is used where certain waters would dissolve lead with resulting danger of lead poisoning. It is also used in industrial plants for pipes conveying liquid pulp, mineral waters or liquids which have a dissolving action on other metals. Lead lining is not as expensive as tin and is used for waters that would incrust or corrode plain iron pipe, but do not affect lead lining. Cement lining is less expensive than lead or tin and is used to good advantage for large mains as well as small service pipes.

Wherever iron or steel is used it is benefited by some surface coating for the prevention of rust. Cast iron pipe is usually covered with a tar pitch varnish applied in accordance with the specifications of the American Water

Works Association. Wrought iron and wrought steel service pipe is usually "galvanized." The galvanizing process consists of first immersing the pipe in a bath of sulphuric acid then washing off all traces of the acid and immersing the pipe in a bath of molten zinc heated to a temperature of 800 deg. Fahr.; the weight of zinc adhering to the pipe is from 2 to 3 ounces per square foot of surface.

A considerable number of proprietary pipe coatings are now on the market. Some of these appear to have merit, and should be considered and investigated where conditions of soil or pipe metal make some form of exterior pipe protection advisable. In general coatings of this nature have not been found adequate to prevent corrosion although they are of some benefit in retarding it.

The tar pitch and galvanized coatings are the coatings most generally used on service pipe and are of benefit in preventing what is usually known as "red" water caused by iron rust, which occurs when the iron surface is exposed.

Where unusual installations, such as laying pipe in cinder fills, are considered special coatings, wrappings or encasements may be advisable. Such installations should be studied carefully and the most suitable pipe and methods used that cost conditions will justify.

Present Practice of Railroads and Cities

We sent a questionnaire to many railroads and cities requesting information on the kind of service pipe used by them. A summary of the information received from this questionnaire follows and indicates that large cities are using lead, galvanized iron and steel, copper, brass and castiron with the general preference apparently in favor of lead in sizes up to 1½ inches and cast iron with bell and spigot joints in sizes 2 inches and over. Many cities expressly permit the use of brass, copper and galvanized iron and steel in their code for this work. None of the cities reporting use ungalvanized or "black" wrought iron or wrought steel service pipe.

The cities, as a rule, have carefully detailed plans and specifications for service lines while railway companies, with limited exceptions, reported no detailed plans or specifications and are using any class of pipe available even black steel, which is known to have relatively short life when laid underground. The Illinois Central System, however, reported a specification for protected wrought iron service pipes for new facilities, which is as follows:

"All underground piping 2 inches and under shall be extra heavy galvanized genuine wrought iron pipe. All threads shall be cut clean and all burrs reamed out before connecting. Fittings shall be heavy galvanized malleable iron. All underground wrought iron pipe shall be protected by covering with asphalt and burlap. The asphalt shall be applied hot and pipe then wrapped diagonally with a strip of burlap 6 inches in width. The burlap shall lap 2 inches and shall be coated after wrapping with asphalt. Burlap and asphalt covering shall be continuous and shall cover threads and couplings. No damage shall be done to covering with wrenches or other tools. The back filling around wrought iron pipe shall be sand or clay and shall be carefully packed under pipe to prevent settlement."

Summary of Information Received on Questionnaire

Name of Railway or City	*Kind of Pipe Used*
Union Pacific	Wrought iron and steel, black and galvanized.
Chicago, Milwaukee & St. Paul	Wrought Steel—galvanized.
Illinois Central	Extra heavy wrought iron galvanized and wrapped with burlap and asphalt.
Central of Georgia	Wrought steel, black and galvanized.
Chesapeake & Ohio	Wrought iron—black.
Kansas City Southern	Wrought steel and iron—black and galvanized.
Great Northern	Wrought steel, black and galvanized; small amount cast iron pre-calked joints.
Atlantic Coast Line	Wrought steel—galvanized.
Denver & Rio Grande	Wrought iron, black and galvanized. Some cast iron, bell and spigot.
Louisville & Nashville	Wrought iron, black, wrought steel—galvanized, cast iron with flanged, calked, pre-calked and universal joints.
Missouri-Kansas-Texas	Wrought steel, black and galvanized.
Chicago, Rock Island & Pacific	Wrought steel, black and galvanized.
Southern	Wrought iron, black and galvanized, cast-iron pre-calked.
Pennsylvania	Wrought iron galvanized. Now considering 2-inch pre-calked cast iron.
New York Central	Wrought iron or steel galvanized.
Northern Pacific	Wrought steel galvanized. Have given 1¼-inch pre-calked cast iron a trial but on account of ununiformity of wall thickness this cast iron pipe was not entirely satisfactory. If manufacturers develop a good small cast iron pipe would prefer it to galvanized wrought iron or steel.
Florida East Coast	Wrought steel galvanized.
St. Louis Southwestern	Wrought iron, black and galvanized, lead.
New York, New Haven & Hartford	Wrought iron galvanized. Have made two or three trial installations of pre-calked cast iron—have not, as yet, decided on its qualities.
Chicago, Burlington & Quincy	Steel, black and galvanized.
New York City	Services 2 inches and under—lead. Services over 2 inches—extra heavy galvanized iron or bell and spigot cast iron. Services of any size may be of brass with extra heavy brass fittings. Copper with flanged joints may be used up to 2 inches in size.
Chicago	Services up to 2 inches in size shall be lead. Services 3 inches in size standard bell and spigot—cast iron.
New Orleans	Services up to 1½ inches in size—lead, two inches and over—standard bell and spigot cast iron.
Boston	Services up to 1½ inches—lead, 2 inches and over—standard bell and spigot, cast iron.
Charleston, S. C.	Services up to 2 inches—lead 3 inches—cast iron with bell and spigot or simplex joints. Cement lining sometimes used to prevent incrustation, which exists in this locality.

St. Paul	Services 2 inches and under—copper; 3 inches—standard bell and spigot, cast iron.
Los Angeles	Wrought steel galvanized. Cast iron with screw, flanged and calked joints. Pre-calked cast iron abandoned recently. Lead goosenecks sometimes used for connecting to main. Short runs of copper sometimes used for sewer flush tanks.
Spokane	Wrought iron and steel galvanized. Humastic dip on steel pipe. Are now considering use of copper and cast iron for sizes 2 inches and under instead of present materials.
Springfield, Ohio	New services—brass.

Cost of Various Kinds of Service Pipes

As the relative cost of materials is usually of interest we quote the prices of the various kinds of pipe considered as of April, 1927. These prices are nominal f.o.b. foundry or mill in carload lots and are subject to change.

	Price per 100 Feet				
Kind of Pipe	*¾-inch*	*1-inch*	*1¼-inch*	*2-inch*	*3-inch*
Wrought steel—black	$ 4.26	$ 5.97	$ 8.08	$ 13.00	$ 26.88
Wrought steel—galvanized	5.46	7.75	10.48	16.87	34.88
Wrought iron—black	7.86	11.30	15.29	27.06	52.32
Wrought iron—galvanized	9.72	14.05	19.00	32.68	63.22
Brass	26.02	36.52	53.72	84.38	174.40
Copper	29.15	41.04	60.32	94.86	196.22
Lead	39.44	53.53	67.62	101.43	180.32
Cast iron—bell and spigot	*	*	*	28.00	39.00
Cast iron—universal	*	*	*	26.00	39.00
Cast iron—pre-calked	*	*	22.50	22.50	41.00
Cast iron—threaded	*	*	22.50	25.50	41.00

NOTE: *Not manufactured in this size.

BIBLIOGRAPHY

Much has been written on the durability and general suitability of cast iron, pure wrought iron, wrought steel, copper, lead, and brass for small service lines.

A considerable portion of these reports has been written by the technical staffs of the various producers; other reports have been written by representatives of the users, by technical societies through their committees and by independent writers.

The reports written by the producers tend to show great suitability under nearly all conditions for their particular product. These reports sometimes include exposure tests under service conditions as well as accelerated laboratory tests to support the text of the report.

The reports written by the representatives of the users are not so wholehearted in support of any particular material. Their reports tend to show that while some product may be suitable and even pre-eminent in certain locations it does not give satisfaction when used in other locations where the conditions are different.

The reports of the technical committees are mostly in the nature of progress reports, which usually contain information on continued exposure tests of materials under natural conditions of soil and water, which test is preferred to accelerated laboratory tests.

If any of our members wish to obtain more detailed information on the durability of materials for service lines we would suggest the reading of the following reports:

U.S. Bureau of Standards

1926—Corrosion resistence of iron and steel. Letter circular 192. This includes an extensive bibliography on the subject by American and foreign writers.

1923—Protective metallic coatings for the rust proofing of iron and steel. Circular letter 80.

American Society Mechanical Engineers—Journal

1918—Relative corrosion of cast iron, wrought iron and steel pipe in house drainage systems by W. P. Gerhard, Vol. 40, page 945.

Engineering News-Record

1925—Half of Lowell service pipes changed in 52 years, R. J. Thomas, Vol. 95, page 1041.

National Research Council

Research information surveys on corrosion of metals as follows:
1923—Nickel.
1923—Aluminum.
1923—Copper.
1924—Zinc.
1924—Tin.
1924—Lead.

American Water Works Association—Journal

1925—Brass and copper for water service and plumbing pipe, Wm. G. Schneider. Copper and Brass, Research Association, New York, Vol. 14, No. 2, August.

1925—Copper service pipe, W. Twaits, Mueller, Limited, Sarnia, Canada, Vol. 14, No. 3, September.

1925—Experiences with small service pipes, J. E. Gibson, Manager and Engineer, Water Department, Charleston, S. C., Vol. 14, No. 4, October.

1926—Experiences with cement lined cast iron pipe. J. E. Gibson, Manager and Engineer, Water Department, Charleston, S. C., Vol. 16, No. 4, October.

1926—A comparison of service pipe materials, O. B. Mueller, President, Mueller Brass Company, Port Huron, Michigan, Vol. 16, No. 4, October.

American Railway Engineering Association—Proceedings

1926—The design, construction and maintenance of pipe lines. A committee report. Vol. 27, page 221.

American Society for Testing Materials—Proceedings

1918-1925—Progress Reports of Committee A-5 on Continued Exposure Tests of Various Metals.

American Foundrymen's Association—Transactions

1924-1925-1927—Progress reports on soil corrosion of pipes.

The reports of the Bureau of Standards are the most extensive and useful on this subject. The Bureau has selected 46 kinds of soil for tests located in 32 widely separated places in the United States. Types of commercial pipes were buried, including cast iron, wrought iron and wrought steel. Six complete sets of pipes were buried and are taken up for examination every two years. Under this schedule 14,000 specimens of pipe of 28 varieties have been exposed, each specimen being labeled and numbered.

The types of corrosion varies in different soils. The Bureau has, as yet, arrived at no definite conclusions, but is publishing the information gained in the form of continued reports.

Conclusions

(1) Service pipe materials may be divided into two general classes: The ferrous materials, of which wrought iron, wrought steel and cast iron are examples, and the non-ferrous materials represented by lead, copper and brass. The ferrous materials are cheaper, but the non-ferrous materials are more durable under similar conditions of soil and water.

(2) Cast iron pipe is extensively used for large water mains and is generally more durable than wrought iron or wrought steel. It is now commercially available in 1¼, 2 and 3 inch sizes and we suggest that its use for permanent service lines in these sizes be considered.

(3) Extra heavy galvanized wrought iron pipe is suitable for service lines of a semi-permanent nature or for pipe sizes not available in cast iron. Galvanized steel may be considered where the installation is intended to last for a relatively short period.

(4) We do not recommend black wrought iron or steel pipe for service lines on account of the relatively lower durability and the tendency of the uncoated metal to rust and cause discolored water.

(5) Where service lines one inch, or less, in sizes are laid under pavements or in other locations where an indefinitely permanent installation is required we suggest the use of copper pipe, or brass pipe with 85 per cent copper content in preference to lead pipe for the reasons that such pipe is cheaper and stronger than lead, fully as durable, and easier to install owing to the absence of the "wiped" joint.

(6) The pre-calked joint for cast iron pipe in 1¼, 2 and 3 inch sizes is a convenience and economy over the older method of installing the molten jointing material in the field. While pipe users have not fully accepted it, we believe their reluctance is largely due to a natural hesitation in superseding an established process until someone else has fully tried out the newer method. We suggest small trial installations of pre-calked cast iron pipe in 1¼, 2 and 3 inch sizes by railways interested to fully test it.

(7) We do not recommend the use of any form of calked joints under railway tracks without encasement or other protection against vibration.

(8) The universal cast iron joint in 2 and 3 inch sizes should be considered for use in partially settled fills or in locations subject to vibration or movement where protective measures are not provided, as this class of joint will adjust itself to considerable disturbance without leakage.

(9) Where service pipe is laid in cinders or corrosive soils or where the water has an unusual tendency to corrode or incrustate a special study should be made to select the piping material and protective methods best suited for the conditions.

(10) It is our opinion that too many pipe sizes are now used for service lines and we believe that railways should limit these sizes to a suitable minimum.

Appendix G

(7) USE OF GRAVITY AND PRESSURE FILTERS

D. A. Steel, Chairman, Sub-Committee; C. M. Bardwell, S. C. Beach, R. E. Coughlan, B. W. DeGeer, H. W. Faus, J. M. Fitzgerald, O. T. Rees, R. W. Savidge, R. A. Tanner.

Committee reports progress.

Appendix H

(8) DISPOSAL OF SLUDGE AT WATER SOFTENING PLANTS

R. E. Coughlan, Chairman, Sub-Committee; R. A. Baldwin, R. W. Chorley, J. H. Davidson, S. C. Johnson, P. M. LaBach, J. R. Hickox.

The disposal of sludge from water softening plants is one of the problems with which the railways operating lime and soda-ash softening plants have to contend. In some cases, this sludge has become a possible menace to the railway companies, as the property-owners in the vicinity of the softening plants sometimes raise serious objections when this material happens to get on their land. Some of the cities have also forbidden its disposal through municipal sewers.

In an endeavor to solve the problem of its disposal, your Committee has canvassed practically all of the railways operating softening plants as well as some of the municipalities which use this method of water softening.

Analysis of this material on a water-free basis shows that it consists principally of calcium carbonate, with varying percentages of magnesium hydrate. It also contains the mud, sand and other impurities which were originally in the water as suspended matter. When it is removed from the softening plants, it contains 80 to 90 per cent of water. This water upon evaporation leaves the sludge in the form of a whitish or brownish white paste or powder, depending upon how much of the water is retained.

The general method of its disposal, wherever possible, is to allow it to drain out of the plant onto low ground or into a creek or moving body of water. Where this is not practical, it is necessary to construct pits to retain the sludge until such time as these pits are cleaned by clam shell or other means at considerable expense. The sludge is then hauled in cars to a suitable disposal ground, or mixed with cinders or other refuse for convenient disposal. Where pits are necessary, it has been found advantageous to build them in two or more water-tight compartments, so that after the sludge has settled the water is pumped back into the softening plant.

In many cases the sludge is simply dumped along the right-of-way or allowed to accumulate in piles which are scattered to some degree by the wind. At several points it has been found that piling the sludge upon ground slightly higher than the surrounding country greatly aids in its disposal, as it dries quickly and disappears quite rapidly.

Some railways have specially designed sludge disposal cars. These are made out of a tank car, putting 8-inch quick opening gate valves in on opposite sides of the car, near the bottom towards each end. A 2-inch perforated pipe runs the full length of the car on the bottom; with a gland at one end and a stuffing box. This pipe has quarter-inch holes about 10 inches apart on the bottom. When the car has been hauled out to the disposal ground, the perforated pipe is connected by means of a hose to the

blowoff cock of the locomotive handling it. Water and steam are blown into the car in order to stir up the sludge, after which the gate valves are opened and the car empties itself.

Some of the uses to which this sludge has been applied with varied success are:

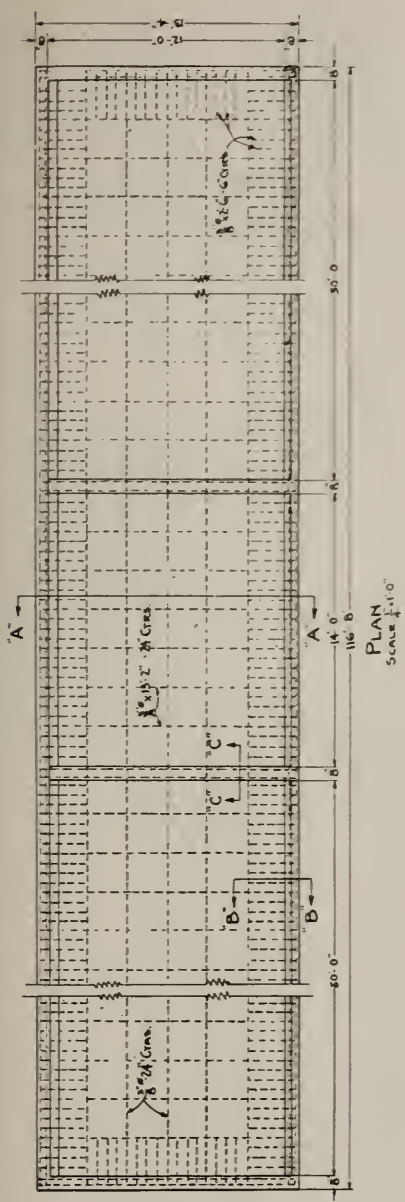
Reburning.—Reburning the sludge to convert it back to calcium oxide results in a recovered calcium oxide of poorer quality than the original commercial product. The expense incurred in hauling the sludge to a central point prohibits the extensive use of this method.

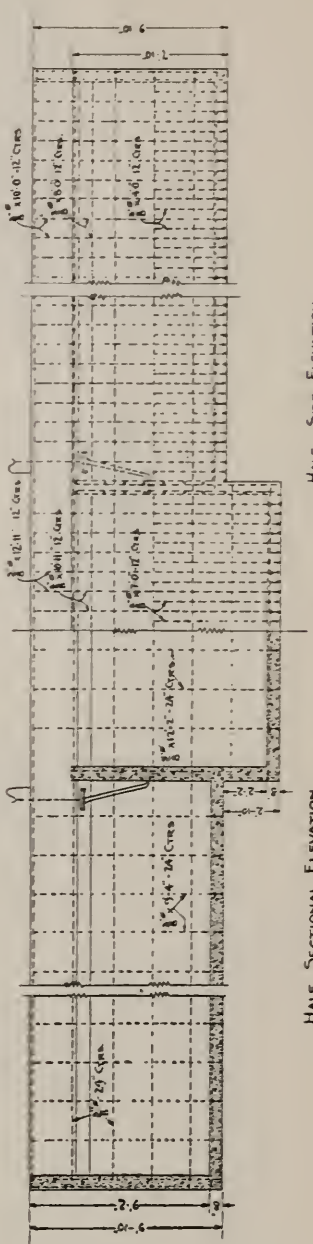
Whitewash.—This sludge is not as economical or as efficient as the ordinary commercial lime sold for this purpose. It can, however, be used as a "filler" for the whitewash as well as mortar.

Chalk and Toothpaste.—A small quantity of the sludge has been used in the manufacture of chalk. The commercial raw materials at present used for these products are far superior to the sludge.

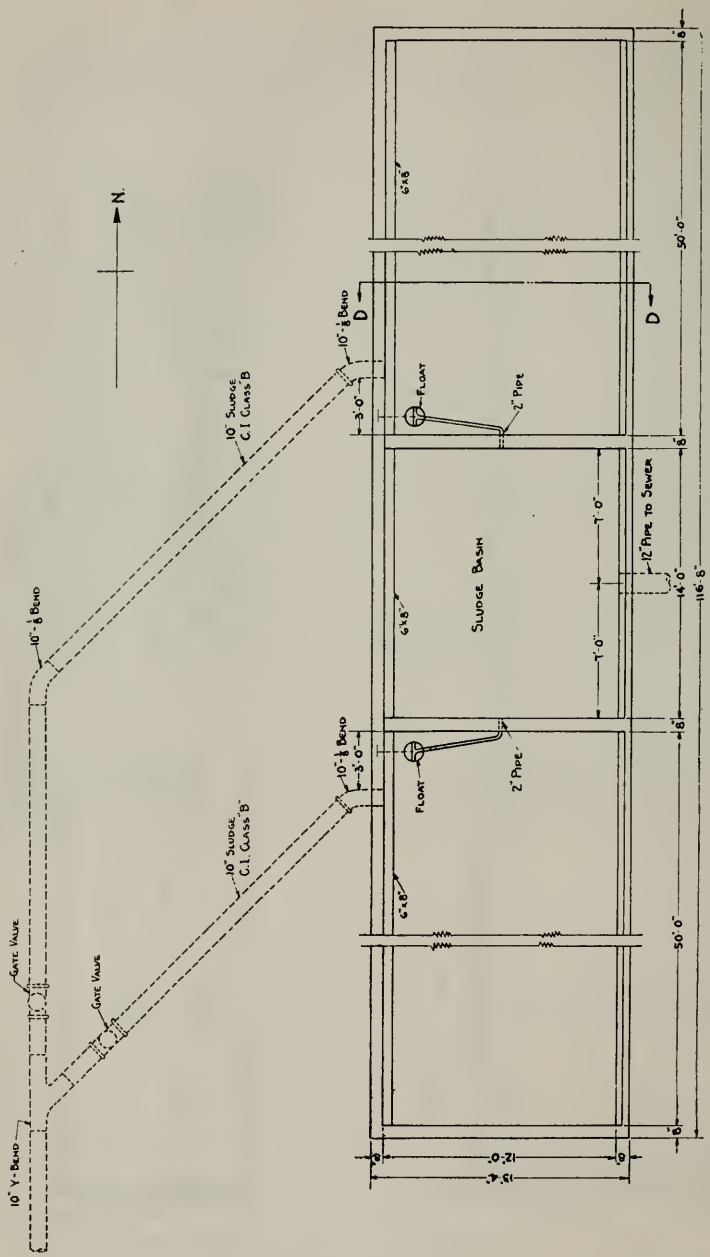
Fertilizer.—This appears to be the only economical method of disposal of this material where sludge pits are necessary. It is an excellent antidote for "sour land." The difficulty of its use is due to its consistency which makes it difficult to distribute it uniformly over the land with the present farm machinery. A campaign of education is necessary among the agricultural agents to get them interested enough to solicit demand from local farmers. A common experience has been that a small percentage of the sludge will be hauled away gratis by farmers living in the vicinity of the softening plant, but in order to make this method of any value its use must be advertised on a larger scale.

It is the opinion of your Committee that the most economical method of disposal of this sludge is to allow it to drain away onto low land or into a moving body of water. At points where pits are necessary, a united effort should be made to interest agricultural agents in the use of this material as a fertilizer, allowing them to take it away at their own price.



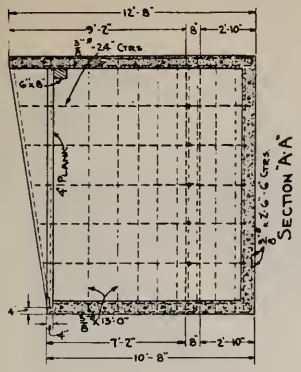


PLAN OF SLUDGE BASIN FOR WATER SOFTENING PLANT

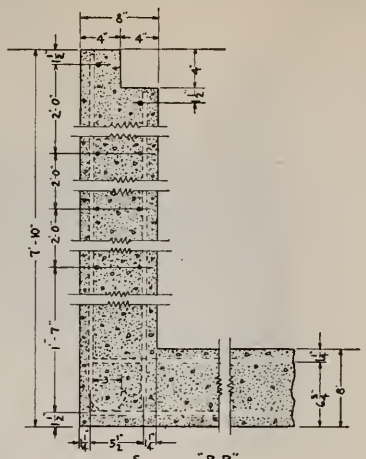


Plan Showing Location of Pipes

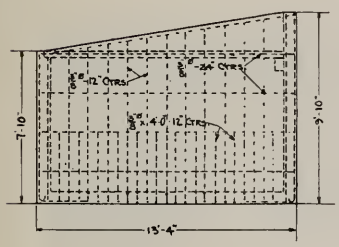
Plan of Sludge Basin for Water Softening Plant



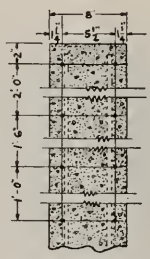
SECTION "A-A"



SECTION "B-B"
SCALE: 1 1/2" = 1'-0"



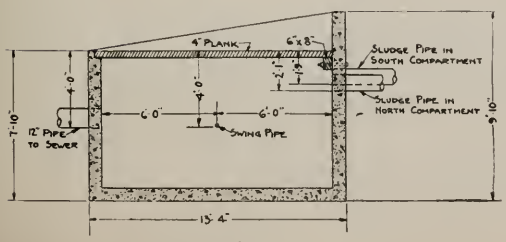
END ELEVATION



SECTION "C-C"
SCALE 1 1/2" = 1'-0"

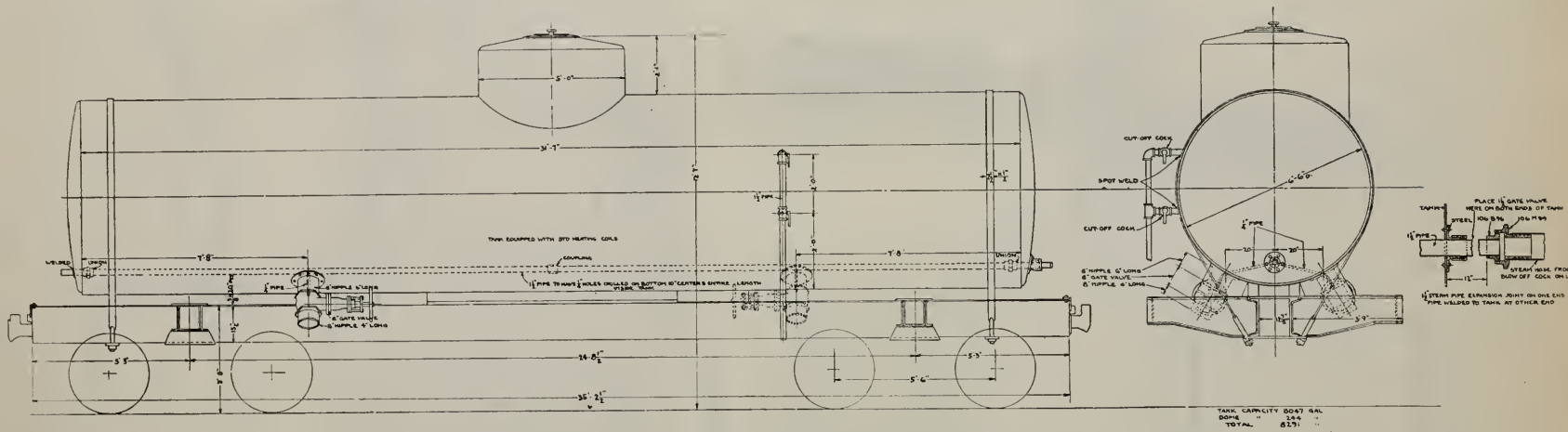
NUMBER OF STEEL RODS REQUIRED

224	3/8" ø x 4'-0"	———	OUTSIDE OF END WALLS AND OUTSIDE OF SIDE WALLS	
98	3/8" ø x 8'-0"	"	" " SIDE " EAST SIDE "	
98	3/8" ø x 10'-0"	"	" " " " WEST "	
28	3/8" ø x 7'-0"	"	" " " " MIDDLE PART	
13	3/8" ø x 10'-11"	"	" " " " WALL " " EAST SIDE	
13	3/8" ø x 12'-11"	"	" " " " " " WEST "	
2	3/8" ø x 8'-2"	"	" " END WALLS	
2	3/8" ø x 8'-4"	"	" " " " "	
2	3/8" ø x 8'-6"	"	" " " " "	
2	3/8" ø x 8'-8"	"	" " " " "	
2	3/8" ø x 8'-10"	"	" " " " "	
2	3/8" ø x 9'-0"	"	" " " " "	
2	3/8" ø x 9'-2"	"	" " " " "	
2	3/8" ø x 9'-4"	"	" " " " "	
2	3/8" ø x 9'-6"	"	" " " " "	
2	3/8" ø x 9'-8"	"	" " " " "	
2	3/8" ø x 9'-10"	"	" " " " "	
2	3/8" ø x 8'-1"	STRAIGHT	INSIDE " " "	
2	3/8" ø x 8'-5"	"	" " " " "	
2	3/8" ø x 8'-9"	"	" " " " "	
2	3/8" ø x 9'-0"	"	" " " " "	
2	3/8" ø x 9'-4"	"	" " " " "	
48	3/8" ø x 7'-4"	"	" " SIDE WALL EAST SIDE	
48	3/8" ø x 9'-4"	"	" " " " WEST "	
6	3/8" ø x 10'-2"	"	" " " " MIDDLE PART EAST SIDE	
6	3/8" ø x 12'-2"	"	" " " " " " WEST "	
20	3/8" ø x 10'-6"	"	BOTH SIDES OF CROSS WALLS	
110	3/8" ø x 13'-2"	"	TOP OF BOTTOM SLAB OUTSIDE AND INSIDE OF END AND CROSS WALLS	
92	3/8" ø x 26'-6"	"	" " " " " " " " SIDE WALLS	
27	3/8" ø x 15'-2"	"	" " " " " " " " " " " MIDDLE PART	
484	3/8" ø x 2'-6"	"	BOTTOM OF BOTTOM SLAB	



SECTION "D-D"

PLAN OF SLUDGE BASIN FOR WATER SOFTENING PLANT



Sludge Tank Car

Typical Sludge Piles

Appendix I

(9) DESIGN AND MAINTENANCE OF TRACK PANS FOR LOCOMOTIVES

E. G. Lane, Chairman, Sub-Committee; H. W. Faus, W. B. McCaleb, A. B. Pierce, F. D. Yeaton.

Committee reports progress.

Appendix J

(10) METHODS USED IN OBTAINING SUCCESSFUL WELLS IN FINE SAND FORMATION

J. R. Hickox, Chairman, Sub-Committee; B. W. DeGeer, R. L. Holmes, J. M. Fitzgerald, H. W. VanHovenberg, F. D. Yeaton.

Committee reports progress.

Appendix K

(11) ECONOMICAL SPACING OF WATER STATIONS IN CONNECTION WITH INCREASING CAPACITY OF ENGINE TENDERS

R. C. Bardwell, Chairman, Sub-Committee; C. M. Bardwell, B. W. DeGeer, E. M. Grime, J. P. Hanley, R. L. Holmes, F. H. Kornfeld, H. H. Richardson.

The economical spacing of water stations in connection with increasing capacity of engine tenders is largely a question pertaining to possible operating economies on the individual district concerned. Special study is required for the individual freight train sub-divisons under consideration, and a general report of this character can only call attention to the various factors involved.

One of the present measures of freight train operating efficiency is gross ton miles per train hour. An increase in gross ton miles per train hour is produced in two ways: (1) by greater train load, and (2) by accelerating train movement. Acceleration of train movement is directly influenced by the elimination of unnecessary stops which not only delay the train in question but retard the progress of following traffic on busy main line.

One of the means for acceleration of train movement, of which advantage has been taken by a number of railways during the past few years, has been effected by increasing the size of engine tenders with the corresponding elimination of many stops for water formerly necessary.

The advantages to be obtained by the elimination of water stops are, in a large measure, peculiar to the individual district and location. In addition to the time lost in bringing the train to the stop and regaining the original speed, it is customary on heavy tonnage trains to detach the locomotive from the train for taking on water and coal which frequently involves further loss of time in pumping up train line to required pressure and also incident inspection of locomotive and train. Where water is taken in connection with regular schedule stops the deceleration and acceleration loss will not be affected, but the other delays are frequently of much greater extent. Water stops are often complicated by stations located in a sag, which promotes greater wear on the brake equipment in stopping, and increased load on the drawbars in starting. It is frequently necessary to cut trains for crossings where water stops are located in municipalities or where important highway crossings are blocked, with further loss of time. Consideration of average conditions indicates that a time loss of 30 minutes may be expected, including the deceleration and acceleration delays. The approximate coal waste will average about one-half ton and water between 600 to 1000 gallons, which appears conservative, particularly where cold weather may be an influencing factor.

Taking a hypothetical case for an example, it is considered advisable to maintain four intermediate water stations or an approximate 20-mile spacing over a 100-mile engine district where 9000 or 10,000-gallon-capacity

engine tanks are used. Although it might be possible in the majority of cases for the locomotive to skip the intermediate station and make a 40-mile water run, the margin of safety is small, especially in view of possible emergency delays which would involve cutting and running for water, so that, under ordinary operating conditions, stops will be made at each water station with incident losses.

With the use of 16,000-gallon-capacity engine tenders, one water stop only should be necessary with ample margin of safety to provide for emergency, thus eliminating three water stop delays. With the use on such district of 22,000-gallon-capacity tenders, the largest size reported to be in use in this country, it should be possible to make the terminal-to-terminal run without stop for water under full tonnage conditions.

The elimination of three water stops should reduce the train time over the district approximately one and one-half hours with corresponding increase in gross ton miles per train hour and also a corresponding increase in the availability of the equipment. Coal saving should approximate 1½ tons, and water between 2000 and 3000 gallons. Wages of train and engine crews, accounts 392 and 401, will not be affected except where they are on the overtime rate. Other saving will be made in account 399, "lubricants and other supplies for train locomotives"; accounts 308, 309 and 310, pertaining to costs of locomotive repairs, depreciation, and cost of ownership; and in accounts 314, 315, and 316 pertaining to freight train car repairs, depreciation, and cost of ownership, as outlined by the Committee on Economies of Railway Operation, appearing as Appendix B in the Committee report to the twenty-eighth annual convention held in March, 1927, on "Study of the Costs of Starting and Stopping Trains."

In addition to the economies in train operation through reduction in stops for water, there will also be an additional saving in elimination of water station cost where such stations may be abandoned. The actual power cost for furnishing the water used will be only slightly changed, but the fixed charges, such as labor and attendance, together with the maintenance costs of the abandoned station will be eliminated. The longer runs should also permit a better selection as to quality of the supply which should prove advantageous in many cases.

From the possible savings which may be derived by the elimination of water stops the additional expense must be subtracted for hauling the added weight of the larger engine tank and water, and for the interest and depreciation on the increased investment in equipment.

In considering the additional expense for hauling the additional weight of the greater capacity tenders, the fixed charges such as crewtime and terminal attention, will not be affected appreciably. The additional cost for fuel, water, and lubricants can be prorated on a tonnage basis.

The maintenance costs for the larger tenders does not greatly exceed those of the smaller capacity. Except in the largest size, the axle load on the 6-wheel truck does not exceed the wheel load on the 4-wheel truck used on the 9000 and 10,000 gallon tanks, so that the wear and replacements will not be appreciably increased.

The interest and depreciation charges on the additional investment will depend upon the type and capacity selected. Following is estimated cost for respective size tank.

9,000 gallon capacity	$ 9,000
10,000 gallon capacity	10,000
12,000 gallon capacity	12,000
16,000 gallon capacity	15,000
22,000 gallon capacity	18,000

Summary

(1) Determination of the economical size for water capacity in engine tenders can be developed by consideration of the operating requirements on the respective individual engine district on freight sub-division, with view of effecting maximum available increase in gross ton miles per train hour by the acceleration of train movement and elimination of delays caused by stops for water.

(2) The decision as to most suitable engine tender capacity will govern the water station spacing which should be handled with view of expediting regular operation and providing sufficient margin of safety to take care of emergencies and prevent delays from water shortage.

(3) Due to the many variable factors influencing operation and train movement throughout the country, your Committee does not feel that general rules can be formulated at this time for universal application, and recommends that careful study be made of the individual districts under consideration for determination of the possible economies available.

REPORT OF COMMITTEE III—TIES

W. J. Burton, *Chairman;*
F. T. Beckett,
R. S. Belcher,
F. J. Bishop,
M. S. Blaiklock,
W. C. Bolin,
H. F. Brown,
H. R. Clarke,
S. B. Clement,
R. L. Cook,
E. L. Crugar,
H. A. Hampton,
R. S. Hubley,
P. B. Jeffries,
J. E. King,
John Foley, *Vice-Chairman;*
C. S. Kirkpatrick,
M. F. Longwill,
A. F. Maischaider,
W. F. McDonald,
L. T. Nuckols,
H. B. Reinsagen,
J. H. Roach,
J. S. Ruff,
H. M. Tremaine,
J. W. Williams,
R. W. Willis,
W. W. Wysor,
R. C. Young,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of Manual (no recommendation).
2. Anti-splitting Devices (Appendix A).
3. Size of Hole for Pre-Boring (Appendix B).
4. Extent to which Specifications are being adhered to. (No report this year).
5. Renewal of Switch Ties (Appendix C).
6. Report on Substitute Ties (Appendix D).
7. Method of Marking Ties to Indicate Acceptance. (No report this year.)
8. Methods of Tie Acceptance Inspection. (No report this year.)
9. Traffic Unit for Use in Comparing Cross-Tie Life (Appendix E).
10. Data on Average Ties Renewed per Mile of Maintained Track (Appendix F).

Action Recommended

1. That the report on Anti-splitting Devices, Appendix A, be received as information.
2. That the report on proper size of hole for pre-boring, Appendix B, be received and the recommendations adopted for the Manual.
3. That the report on the Renewal of Switch Ties, Appendix C, be received as information this year with the understanding that a recommendation based on the report will be submitted for inclusion in the Manual next year.
4. That the report on Substitute Ties, Appendix D, be received as information.

5. That the report on Traffic Unit, Appendix E, be received as information this year with the understanding that a recommendation will be submitted for inclusion in the Manual next year.

6. That the report on Average Ties Renewed per Maintained Mile, Appendix F, be received as information.

Recommendations for Future Work

1. Revision of Manual.
2. Complete report on anti-splitting devices.
3. Continue investigation and report on extent to which specifications are being adhered to.
4. Make recommendation for the Manual on renewal of switch ties.
5. Report on substitute ties.
6. Report on methods of marking ties to indicate acceptance.
7. Report on methods of tie acceptance inspection.
8. Make recommendation for the Manual on traffic unit.
9. Report data on average ties renewed per mile of maintained track, both with and without the traffic unit adjustment.
10. Define the several species of wood included in the Standard Specifications for Cross-Ties and Switch Ties.

Respectfully submitted,

The Committee on Ties,

W. J. Burton, *Chairman.*

Appendix A

(2) ANTI-SPLITTING DEVICES

E. L. Crugar, Chairman, Sub-Committee; R. S. Belcher, W. C. Bolin, H. R. Clarke, R. S. Hubley, L. T. Nuckols, H. B. Reinsagen.

The Sub-Committee has not completed its investigations on this subject, and cannot make a final report this year. Supplementing the report of last year, the following is submitted as information.

The Committee was fortunate in being able to secure the assistance of the Pennsylvania Railroad laboratory at Altoona and this progress report contains the results of the tests made at Altoona.

Several types of anti-splitting devices were tested in a machine to the point of failure of either irons or wood.

Method of Tests

The tie sections used in these tests were cut to 14 in. length, care being taken to eliminate knots as much as possible. A ¼ in. slot was cut from one end of the block to within 3 in. of the other end. The irons were then pressed into the end of the block so that they extended across the slot and were separated sufficiently to admit the wedge which was used to split the tie. This wedge was 3¼ in. wide, with a 45 deg. point. When pressing the wedge into the tie, the sides of the slot in contact with the wedge were faced with greased sheet iron in order to reduce the effect of friction.

In making the test, the wedge was forced into the slot by the movable head of a testing machine, the stretch of the block across the slot being observed at each 1000-lb. increment of load as registered on the testing machine, until maximum load was reached.

In all, twelve different types, or arrangements, of irons were tested, three samples of each type being used. The tests are accordingly designated as Samples Nos. 1 to 36, inclusive.

The results of these tests are shown by the accompanying charts and photographs.

Sheet No. 18690 shows the relative holding power of the several anti-splitting devices tested. Sheet No. 18691 shows graphically the same data, the load being plotted as ordinates and the stretch across the slot as abscissa.

Photographs T-18249 to T18262, inclusive, and T-18645 to T-18654, inclusive, show the appearance of the samples tested both before and after the tests. The samples are numbered consecutively on the photographs in the same manner as on the data and the curve sheets.

An examination of the photographs, data and curve sheets would indicate the following conclusions:

Tests 1, 2 and 3

"S"-irons with short perpendicular lug at each end—this test shows that the wood in the tie fractures first, away from the heart of the tie. This is to be expected, but in this test the wedges were driven between the "S"-irons, thus supporting the heart wood.

Tests 4, 5 and 6

"S"-irons without perpendicular lugs—with one exception these "S"-irons have slipped on one end, only one tie being fractured, while on Tests 1, 2 and 3 three ties were fractured, indicating greater holding power for the device with the perpendicular lug at the end.

Tests 7, 8 and 9

Two types of "S"-irons were used in this test; slippage of the irons about the same.

Tests 10, 11 and 12

These seem to indicate better holding power for the "S" section than for the oblique bend, even with the lug. This is the condition on Tests 11 and 12; however, on Test 10 the reverse is the case. It would seem that in Tests 11 and 12 the angled end is in good wood at the "S" end, while in Test 10 it is reversed.

Tests 13, 14 and 15

These are shapes prepared in the laboratory and show the disadvantages of having a curve in the device where it crosses the split, as, for instance, in crinkle irons.

Tests 16, 17 and 18

These show greater holding power for right-angled bend, with lug on end, than for standard "S"-iron, but this is not conclusive, inasmuch as right-angled bends were supported by the wedges and also are near the heart of the tie.

Tests 19, 20 and 21

These tests show the superior holding power for "S"-irons with perpendicular lug on the end.

Tests 22, 23 and 24

These tests show the inefficiency of crinkle irons, the bends flattening out at the point of split.

Tests 25, 26 and 27

These tests show the superiority of right-angled bends with perpendicular lugs at the end, as compared to 45 deg. bends with perpendicular lugs at the end.

Tests 28, 29 and 30 and Tests 31, 32 and 33

These tests do not show anything conclusive.

Tests 34, 35 and 36

This test shows greater holding power of devices with right-angle bends where the anchor is at right angles to the radial lines, than where parallel with the radial lines. If the devices had been placed so as to cross the split at right angles, greater holding power probably would have been developed. Some of the movement, no doubt, was due to lateral movement, the devices tending to assume a right-angled position, as evidenced in the photographs.

Conclusions

(1) An anti-splitting device should be straight where it crosses the split or check, rather than curved.

(2) It should cross the split at right angles.

(3) "S"-irons with a small perpendicular lug at the end have more holding power than the standard "S"-irons.

(4) The holding power of a device with a right-angle bend supported by end lug is slightly in excess of the standard "S"-iron with end lug.

The Committee feels that the information derived from these tests is not sufficient to permit definite recommendations as to size and type of irons and therefore no recommendation is made this year.

The Committee wishes to acknowledge the assistance rendered by the Pennsylvania Railroad Company, and by L. J. Riegler, Assistant Engineer.

Sheet No. 18690

Data showing the relative holding power of the several anti-splitting devices tested.

Stretch Across Slot in Wooden Block - Inches.

Load, Lb.	Sample No. 1	2	3	4	5	6	7	8	9	10	11	12
1000	-	-	.031	-	-	-	-	-	.031	.063	-	-
2000	-	-	.031	-	-	-	-	-	.063	.063	.031	.063
3000	-	-	.063	.031	-	.063	.063	.063	.063	.063	.063	.125
4000	.063	.063	.187	.063	.063	.063	.250	.187	.094	-	-	.187
5000	.063	-	-	-	.063	-		-	.375			
6000	.125				-							
7000	-											
Stretch, max. load.	.250	.125	.437	.063	.125	.375	.375	.500	500	.125	.125	.375
Maximum load.	7300	5400	5360	5300	5700	5000	4280	5630	5500	4000	4200	4700
Avg. Max. Load.		6020			5670			5100			4300	

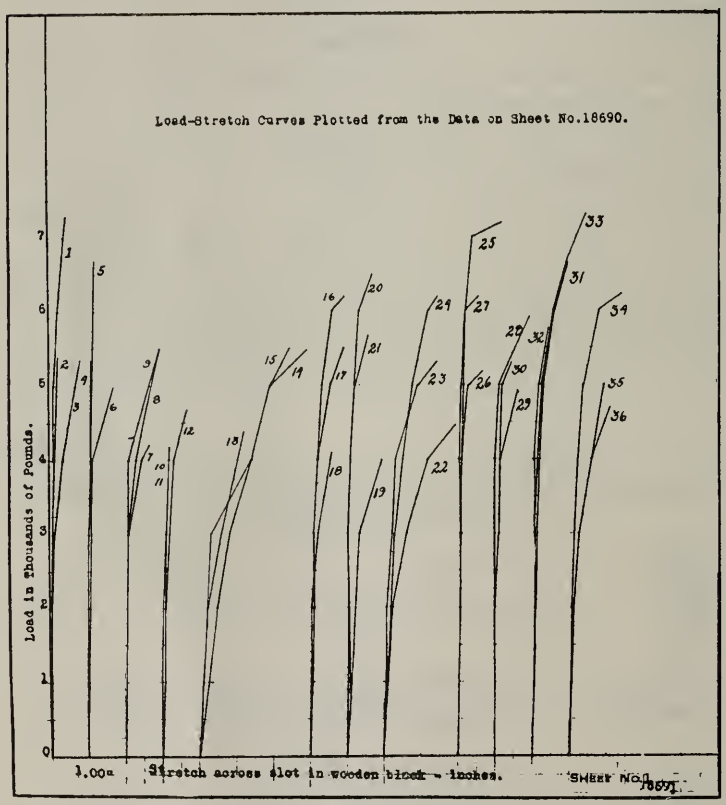
Stretch Across Slot in Wooden Block - Inches.

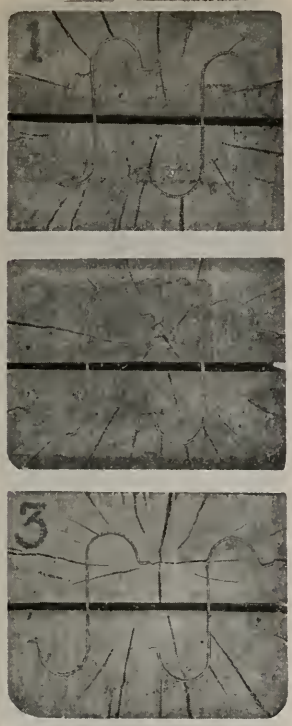
Load, Lb.	Sample No. 13	14	15	16	17	18	19	20	21	22	23	24
1000	.063	-	.125	-	0	.031	.095	-	-	.031	-	-
2000	.125	-	.250	.063	.031	.031	.125	.031	-	.125	.047	.063
3000	.312	.187	.437	.063	.063	.125	.187	.031	-	.312	.125	.156
4000	-	.750	.750	.125	.125	-	-	.063	.063	.625	.187	.281
5000		1.00	1.00	.187	.312			.125	.125		.500	.406
6000				.312				.187				.512
Stretch, max. load.	.625	1.50	1.25	.500	.500	.312	.500	.375	.312	1.00	.750	.750
Maximum Load.	4400	5580	5440	5200	5500	4100	4000	5500	5700	4480	5330	6200
Avg. Max. Load.		5140			5270			5400			5340	

Stretch Across Slot in Wooden Block - Inches.

Load, Lb.	Sample No. 25	26	27	28	29	30	31	32	33	34	35	36
1000	-	.015	-	-	-	-	.031	.015	-	-	.031	-
2000	.015	.031	.031	-	.015	.015	.063	.031	.015	.047	.063	.063
3000	.031	.063	.031	.015	.063	.063	.094	.063	.046	.078	.156	.156
4000	.047	.094	.063	.031	.094	.094	.125	.063	.078	.125	.313	.313
5000	.063	.187	.094	.063		.125	.187	.125	.156	.219	-	
6000	.109		.156				.312		.312	.438		
7000	.250								.625			
Stretch at Max. Load.	.562	.375	.312	.500	.312	.250	.500	.250	.750	.750	.500	.562
Maximum Load.	7260	5270	6200	5920	4930	5300	6650	5700	7300	6220	5000	4700
Avg. Max. Load.		6240			5380			6560			5310	

Sheet No. 18691





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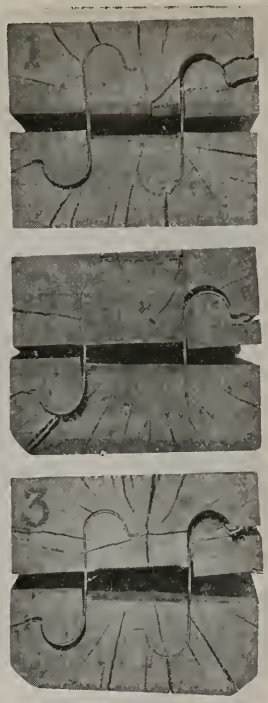

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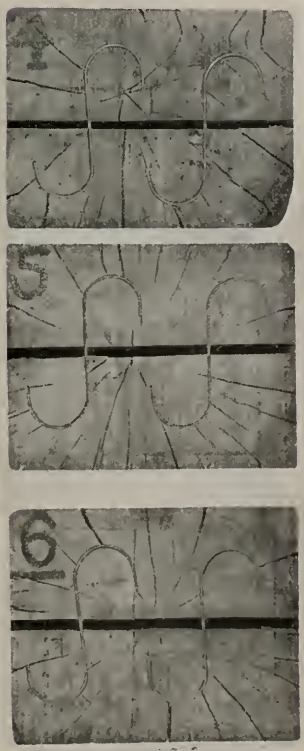

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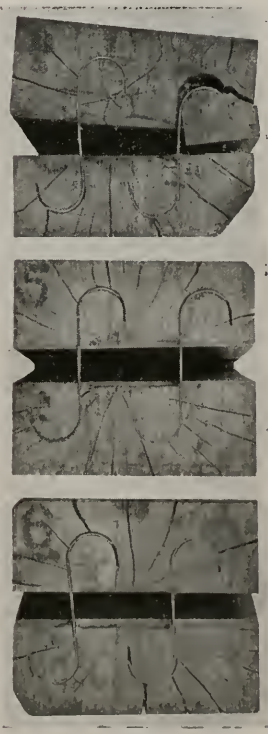

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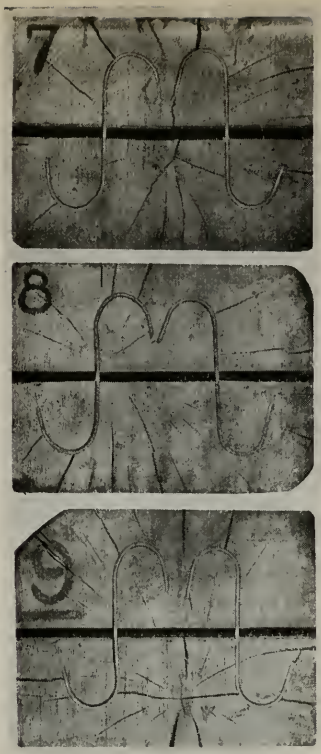

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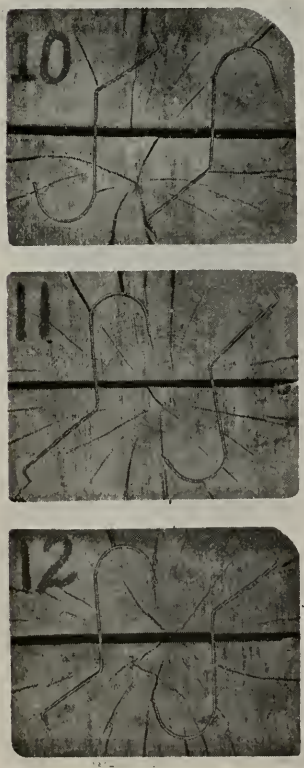

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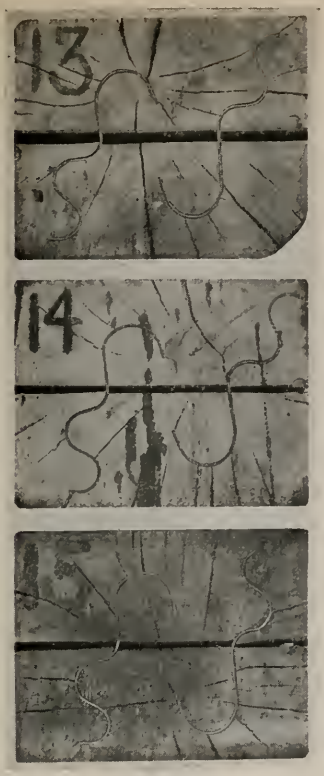

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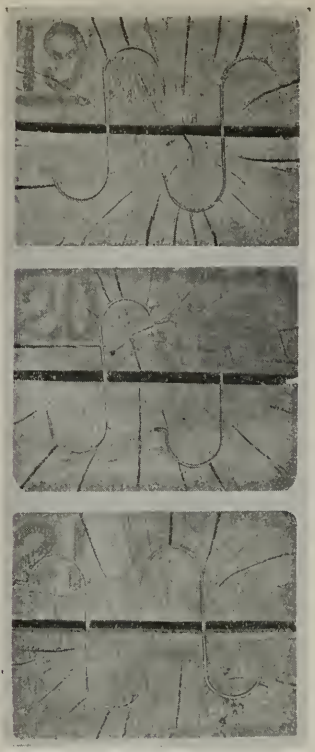

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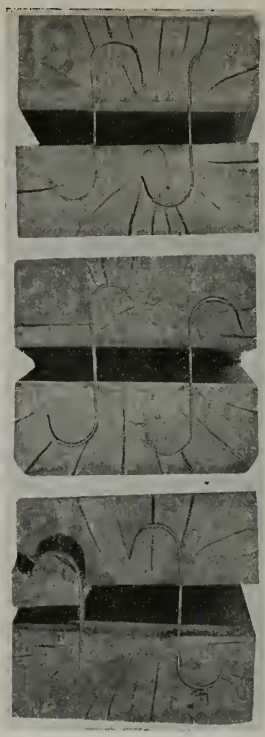

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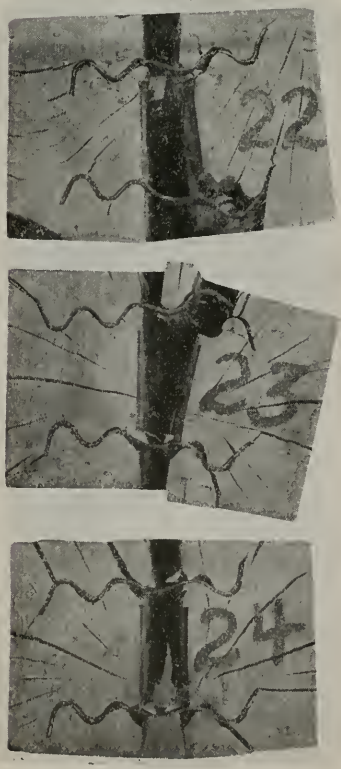

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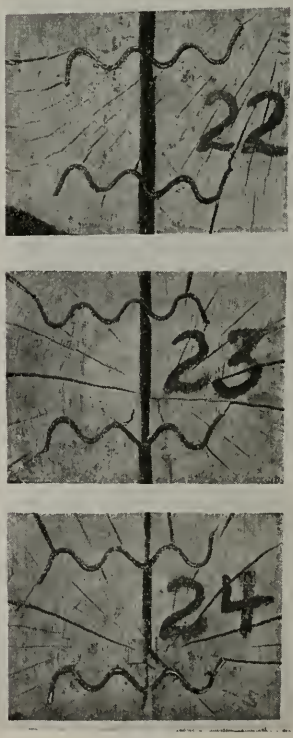

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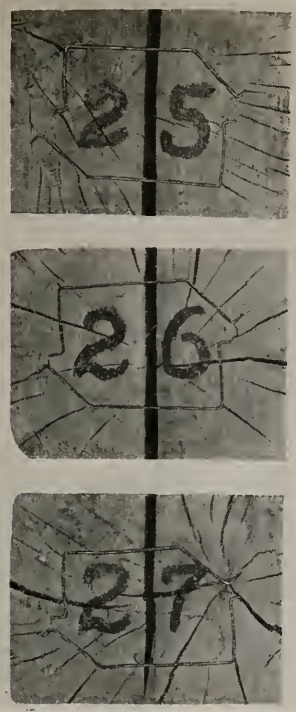

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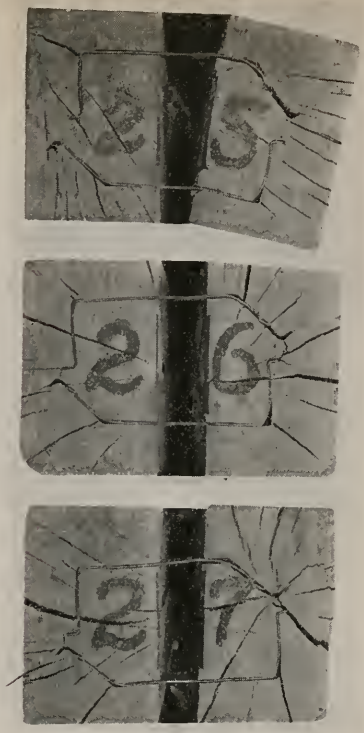

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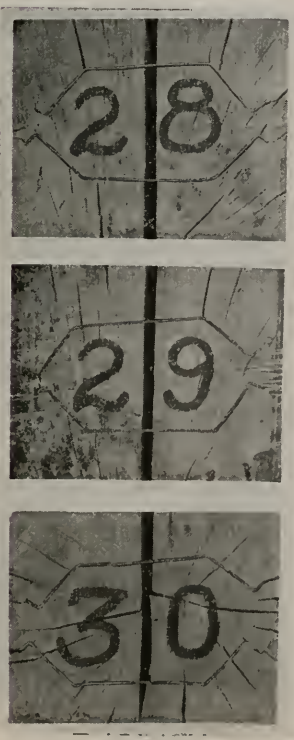

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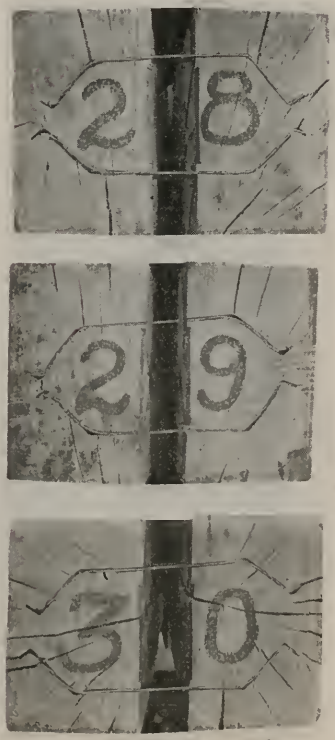

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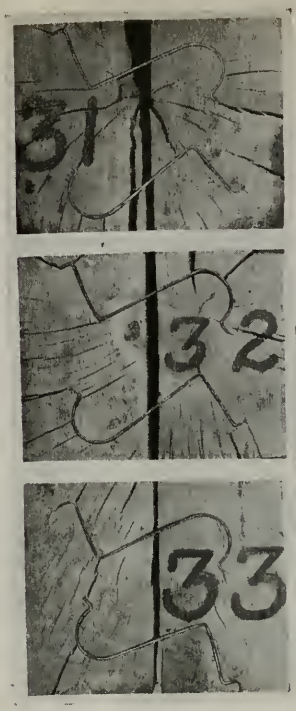

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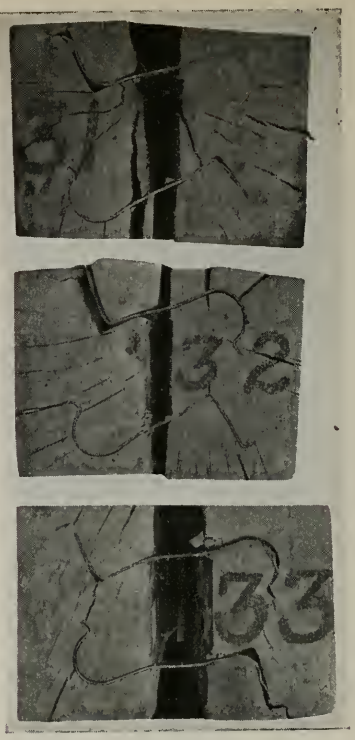

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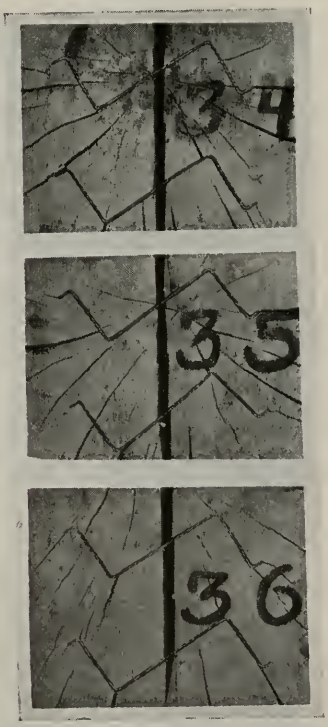

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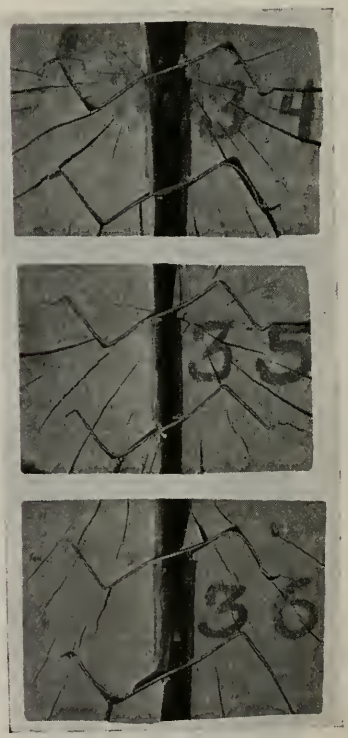

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Appendix B

(3) SIZE OF HOLES FOR PRE-BORING

R. S. Belcher, Chairman, Sub-Committee; F. T. Beckett, J. S. Ruff, W. W. Wysor.

This report is a continuation of report on the same subject last year, in which report mention was made of tests which were then under way to indicate proper size hole for pre-boring. These tests have now been sufficiently concluded to permit a report of results.

This Committee was fortunate in securing the co-operation of the Test Department of the Santa Fe Railway and the assistance of E. E. Chapman, Engineer of Tests. Mr. Chapman's report follows:

SIZE OF HOLE TO BORE FOR TRACK SPIKES

Object

The object of this test was to ascertain the proper size of hole to bore in cross-ties before treating for $\frac{9}{16}$ by 6-in. and $\frac{5}{8}$ by 6-in. cut spikes, as determined by the resistance of the spikes to vertical pull and horizontal thrust when driven into various sizes of holes.

Materials

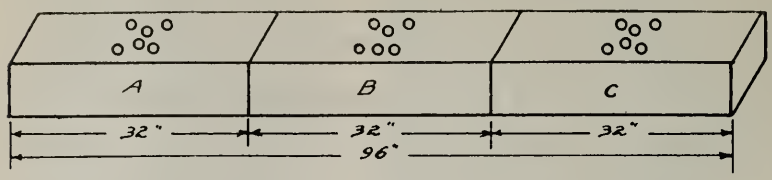
Tests were made to determine the holding power of $\frac{9}{16}$-in. and $\frac{5}{8}$-in. spikes in ten kinds of wood, untreated, creosote treated, and creosote and crude oil mixture treated. The following woods were supplied for this test:

From Somerville, Texas:
- Red oak, hewn ties,
- Red gum, sawn ties,
- Black gum, sawn ties,
- Close-grained short leaf pine, hewn ties,
- Wide-ring loblolly pine, hewn ties.

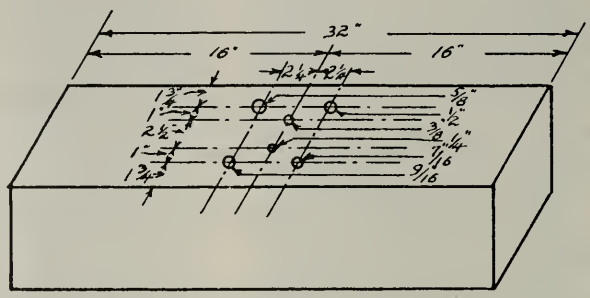
From Albuquerque, N. M.:
- New Mexico pine, hewn ties,
- Red spruce, hewn ties,
- Engleman spruce, hewn ties,
- Corkbark fir, hewn ties.

From National City, Calif.:
- Douglas fir, sawn ties.

Thirty ties of each of the above were supplied, ten of which were fine grain, ten medium grain, and ten coarse grain. The hewn ties had the heart at the center and the sawn ties were what are known as half cut ties. Before they were received for test, the ties were cut in three parts, numbered and bored, as shown in the sketch, Fig. 1. One-third was left untreated, one-third was treated with 5-lb. of creosote per cubic foot, and one-third treated with 8 lb. per cubic foot of 50-50 mixture creosote and oil. Both treatments were of the Rueping process with gain in weight per cubic foot as shown in Table 1.



LAYOUT OF TIE



DETAIL

SKETCHES SHOWING LOCATION AND SIZE OF HOLES

Fig. 1

Table 1.—Summary of Treatment

Kind of Wood	Average Gain in Weight, Lb. per Cu. Ft. Creosote Treated	Mixture Treated
Red oak, hewn	5.92	*7.92
Red gum, sawn	5.11	*7.84
Black gum, sawn	5.18	8.17
Close-grained short leaf pine, hewn	5.65	5.83
Wide ring loblolly pine, hewn	4.37	5.83
New Mexico pine, hewn	5.70	8.30
Red Spruce, hewn	4.36	4.70
Engleman spruce, hewn	6.56	6.00
Corkbark fir, hewn	10.57	8.84
Douglas fir, sawn	5.46	7.81

*—Full cell treatment.

Tests

In order to determine the maximum vertical force required to pull the spikes after being driven into the various sizes of holes, the tie was laid across the fixed head of the testing machine and the spikes pulled with a hook fixed to the moving head, as shown in the photograph, Fig. 2.

Six ties of each treatment were used, two of fine grain, two of medium grain, and two of coarse grain being selected. As far as possible, corresponding thirds of the same ties were used in making the tests on the untreated, creosote treated, and mixture treated ties. In driving the gage was used and all spikes driven until the heads were 7/8 in. from the tie, which had been found to approximate track conditions. In order to split the tie as little as possible, spikes were driven into the 5/8, 9/16, 3/8 and 1/4-in. holes at

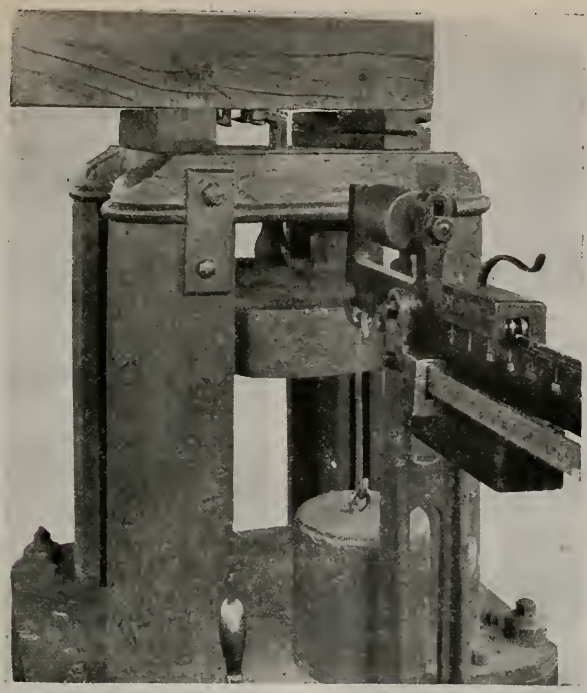


Fig. 2—Photograph Showing Set-Up in Test Machine for Pulling Spikes from Ties

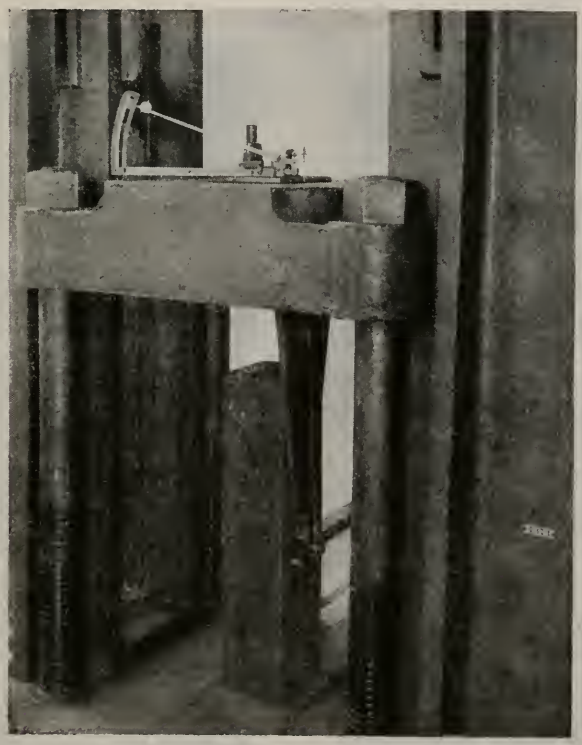
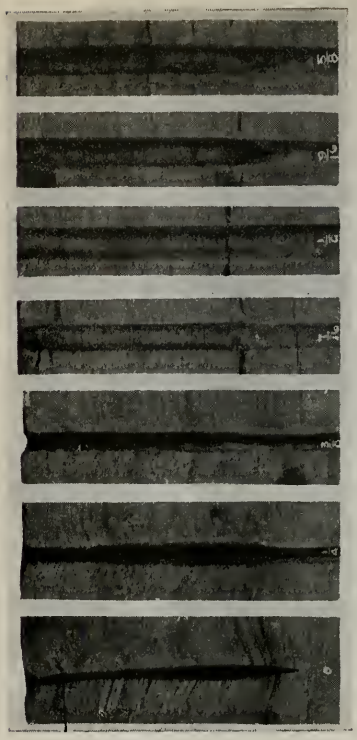
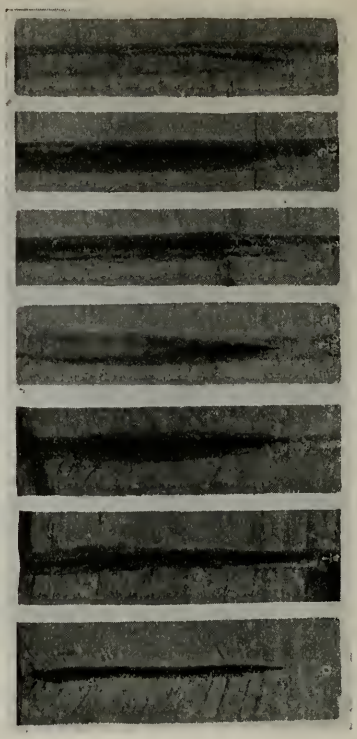


Fig. 3—Set-Up in Test Machine for Loading Spikes in Horizontal Thrust and Measuring Deflection of Spikes

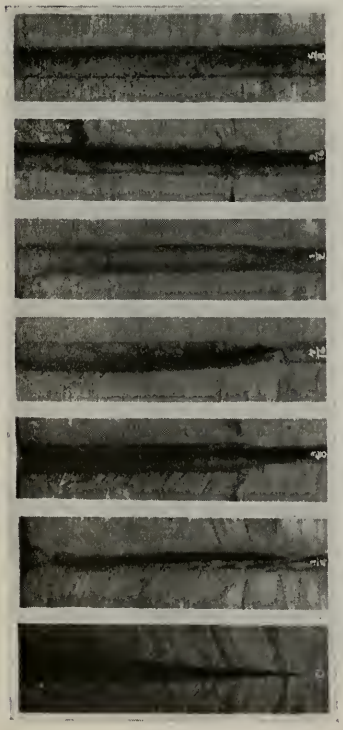


$\frac{9}{16}$-inch Spike

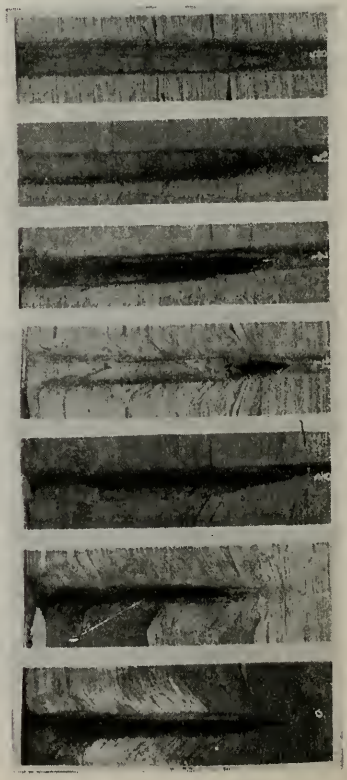


$\frac{5}{8}$-inch Spike

FIG. 4.—Wood fiber distortion in red oak, hewn ties, untreated. Numbers indicate size of bored hole.

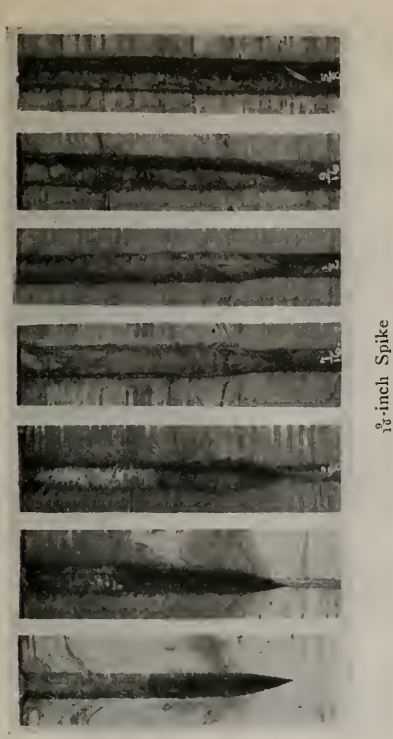


$\frac{9}{16}$-inch Spike

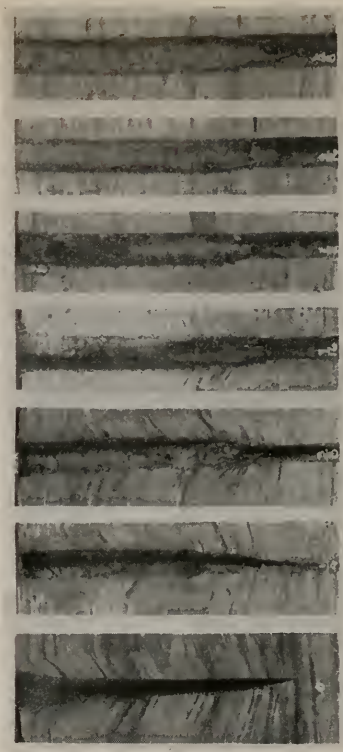


$\frac{5}{8}$-inch Spike

FIG. 5.—Wood fiber distortion in red oak, hewn ties, creosoted. Numbers indicate size of bored hole.

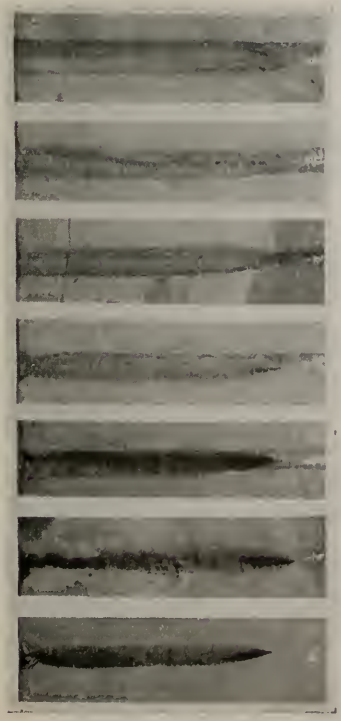


$\frac{9}{16}$-inch Spike

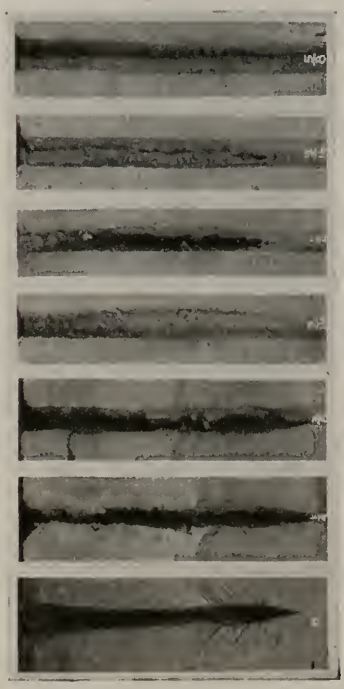


5/8-inch Spike

FIG. 6.—Wood fiber distortion in red oak, hewn ties, mixture treated. Numbers indicate size of bored hole.

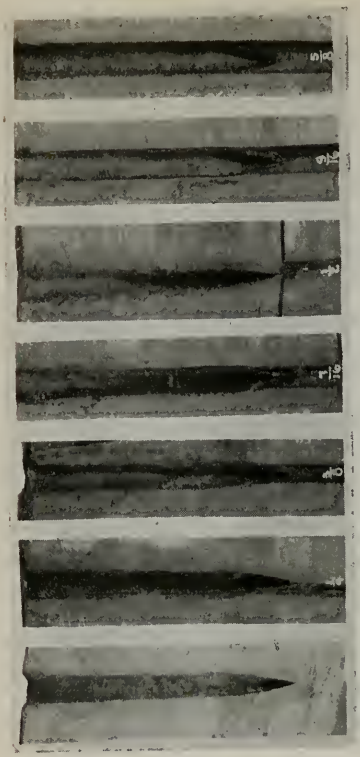


$\frac{9}{16}$-inch Spike

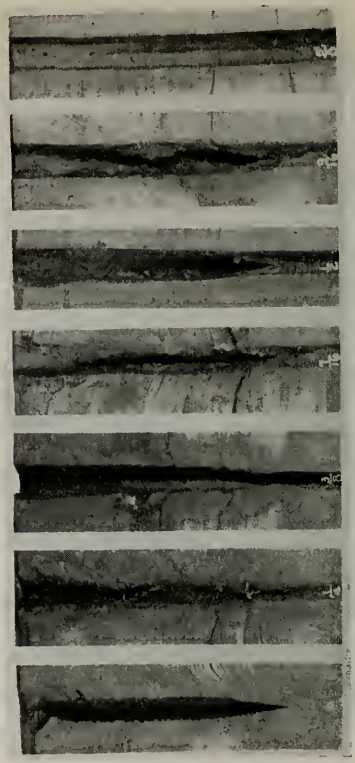


5/8-inch Spike

FIG. 7—Wood fiber distortion in red gum, sawn ties, untreated. Numbers indicate size of bored hole.

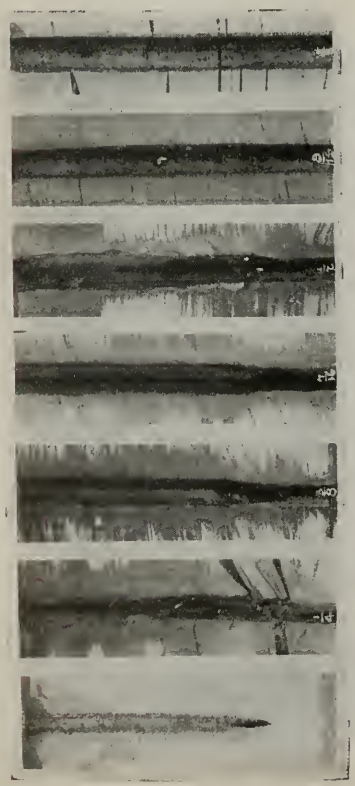


$\frac{9}{16}$-inch Spike

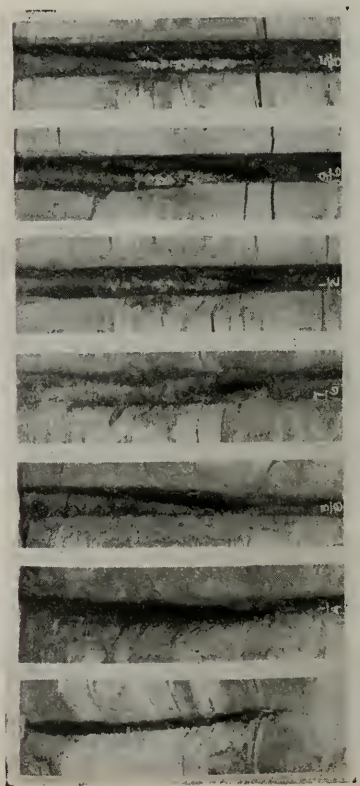


$\frac{5}{8}$-inch Spike

FIG. 8.—Wood fiber distortion in red gum, sawn ties, creosote treated. Numbers indicate size of bored hole.

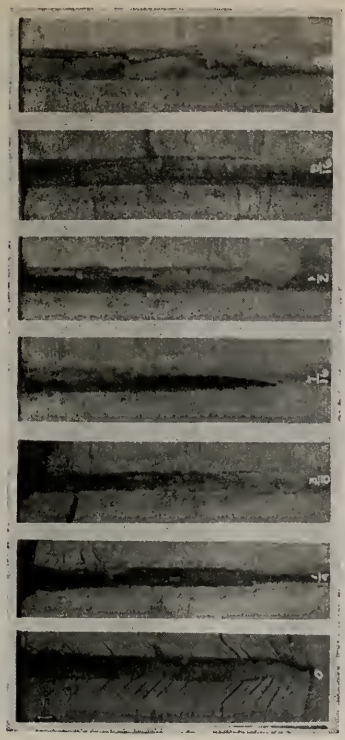


$\frac{9}{16}$-inch Spike

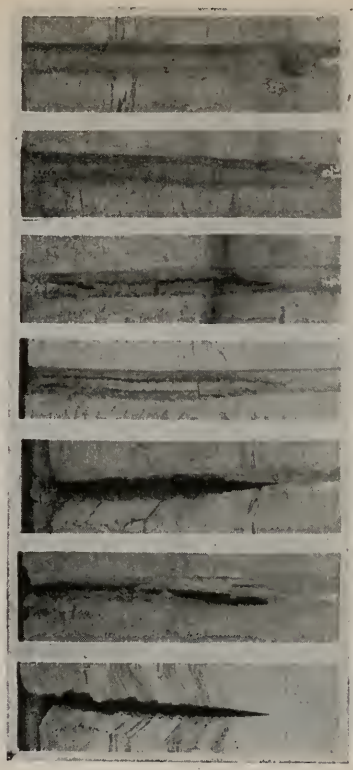


$\frac{5}{8}$-inch Spike

FIG. 9.—Wood fiber distortion in red gum, sawn ties, mixture treated. Numbers indicate size of bored hole.

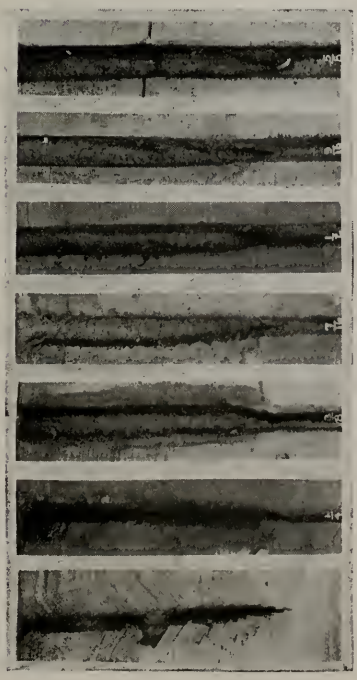


$\frac{13}{16}$-inch Spike

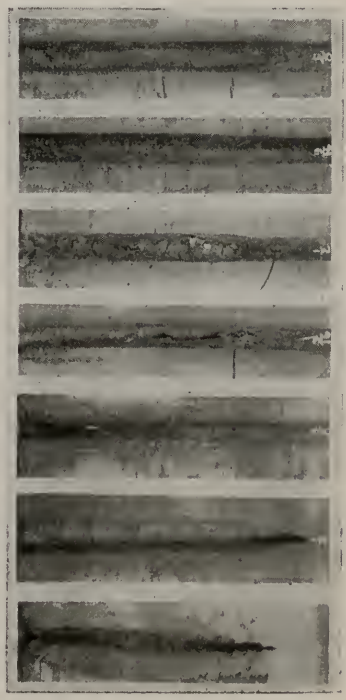


$\frac{5}{8}$-inch Spike

Fig. 10.—Wood fiber distortion in black gum, sawn ties, untreated. Numbers indicate size of bored hole.

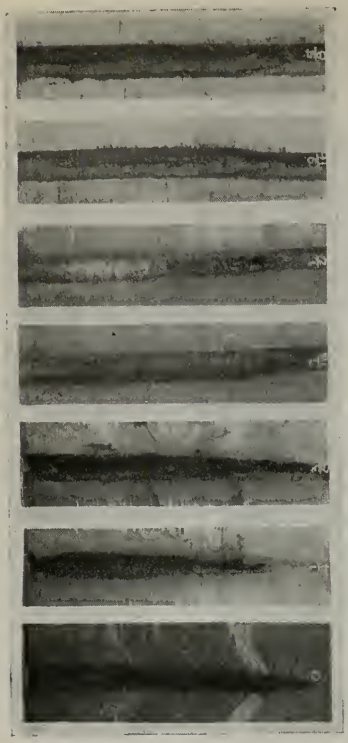


$\frac{13}{16}$-inch Spike

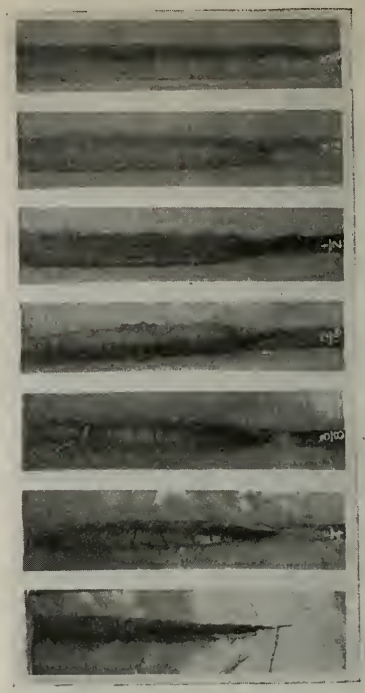


$\frac{5}{8}$-inch Spike

Fig. 11.—Wood fiber distortion in black gum, sawn ties, creosote treated. Numbers indicate size of bored hole.

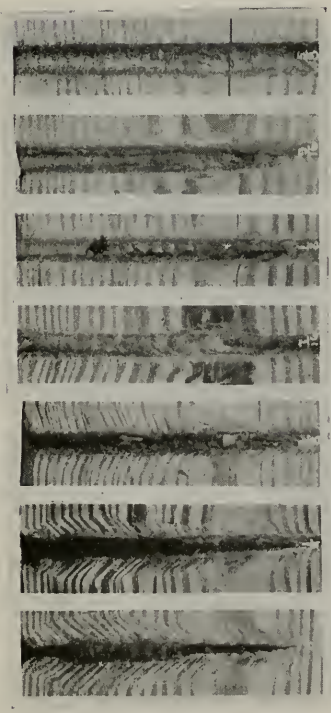


$\frac{9}{16}$-inch Spike

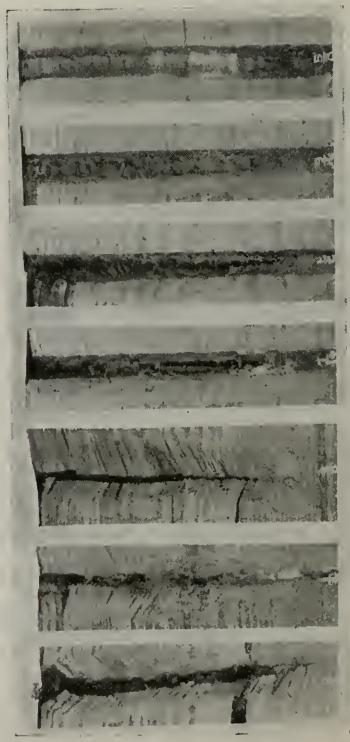


$\frac{5}{8}$-inch Spike

FIG. 12.—Wood fiber distortion in black gum, sawn ties, mixture treated. Numbers indicate size of bored hole.

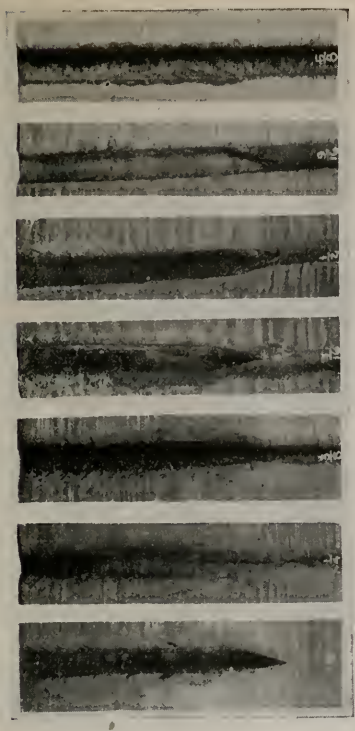


$\frac{9}{16}$-inch Spike

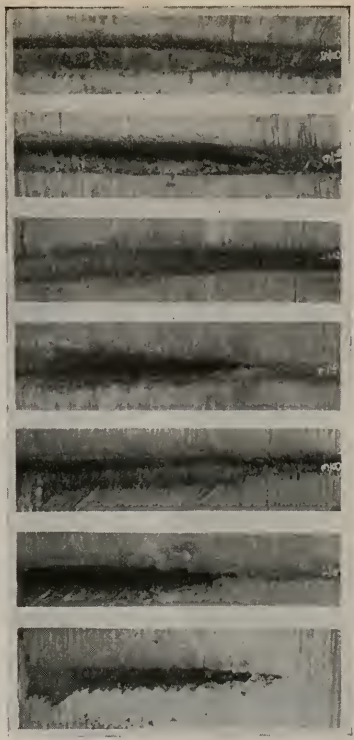


$\frac{5}{8}$-inch Spike

FIG. 13.—Wood fiber distortion in close grained, short leaf pine, hewn ties, untreated. Numbers indicate size of bored hole.

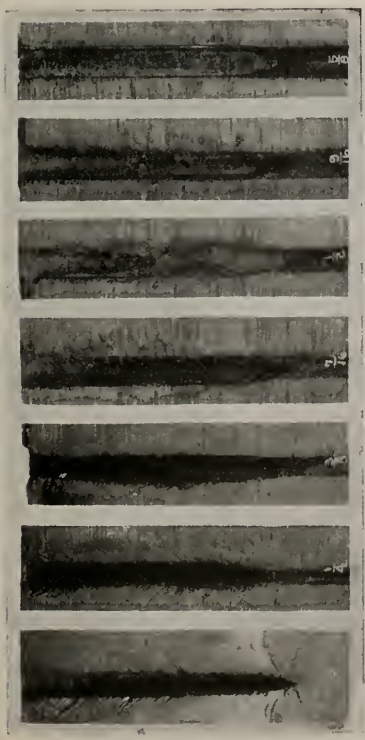


$\frac{9}{16}$-inch Spike

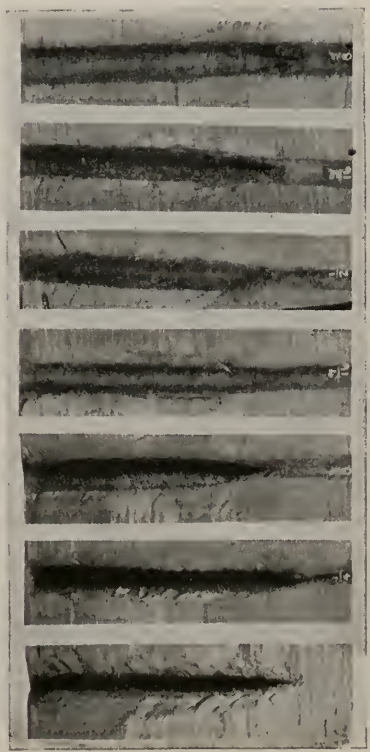


$\frac{5}{8}$-inch Spike

FIG. 14.—Wood fiber distortion in close grain, short leaf pine, hewn ties, creosote treated. Numbers indicate size of bored hole.

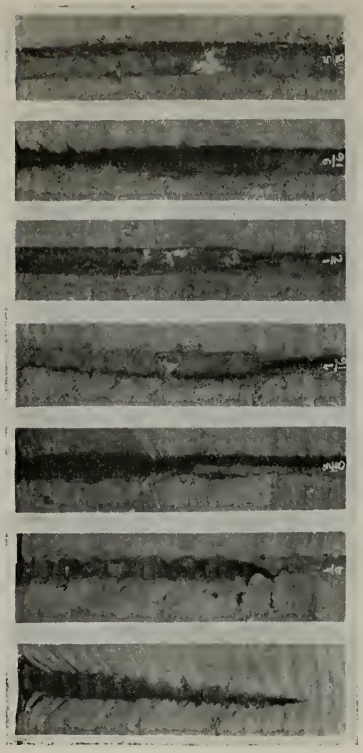


$\frac{9}{16}$-inch Spike

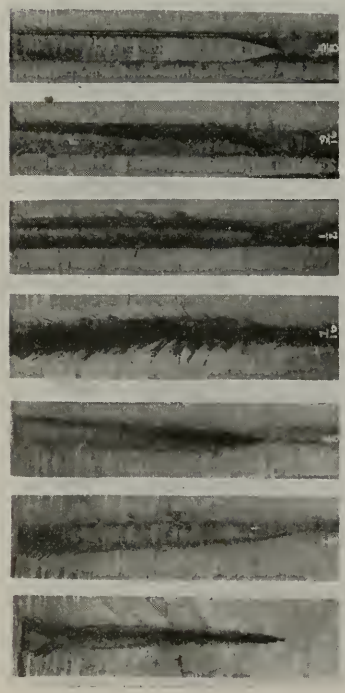


$\frac{5}{8}$-inch Spike

FIG. 15.—Wood fiber distortion in close grained, short leaf pine, hewn ties, mixture treated. Numbers indicate size of bored hole.

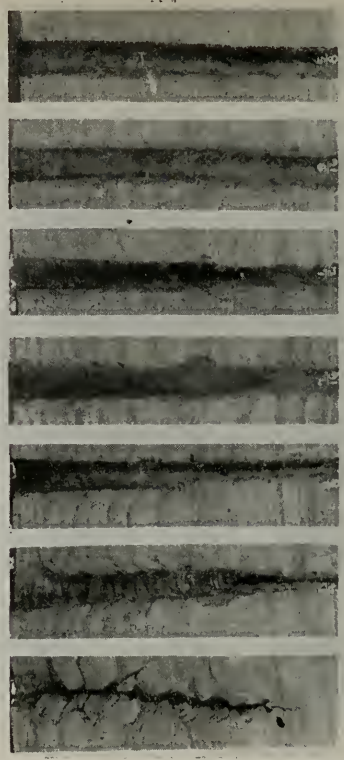


$\frac{9}{16}$-inch Spike

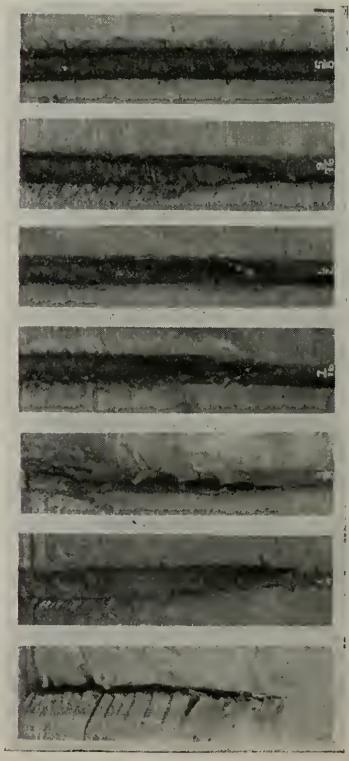


$\frac{9}{16}$-inch Spike

FIG. 17.—Wood fiber distortion in wide ring loblolly pine, hewn ties, creosote treated. Numbers indicate size of bored hole.

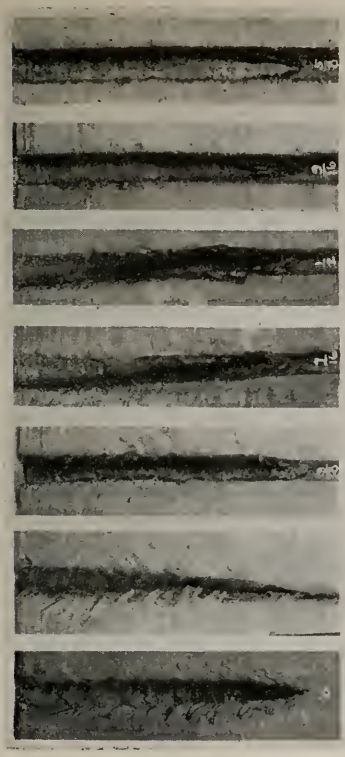


$\frac{5}{8}$-inch Spike



$\frac{5}{8}$-inch Spike

FIG. 16.—Wood fiber distortion in wide ring loblolly pine, hewn ties, untreated. Numbers indicate size of bored hole.



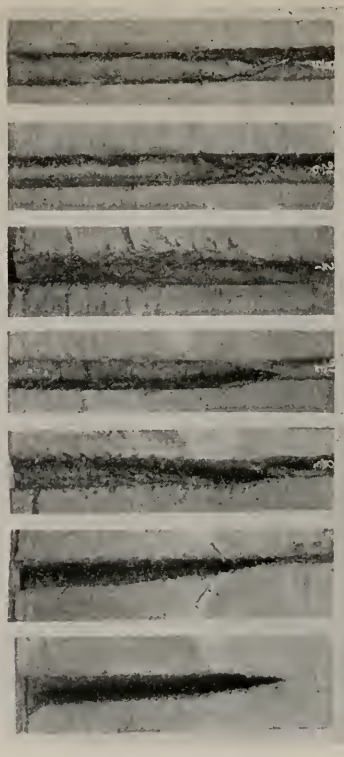
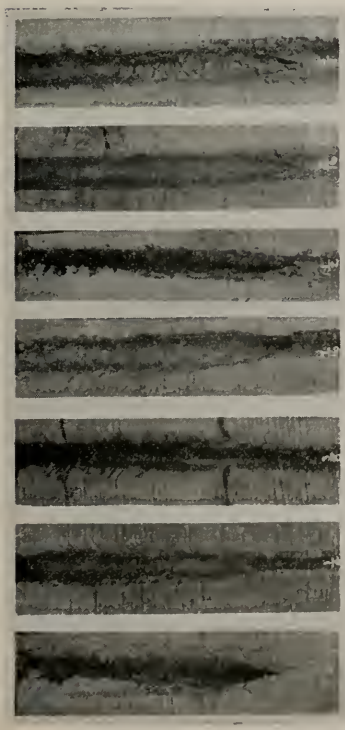


FIG. 18.—Wood fiber distortion in wide ring loblolly pine, hewn ties, mixture treated. Numbers indicate size of bored hole.



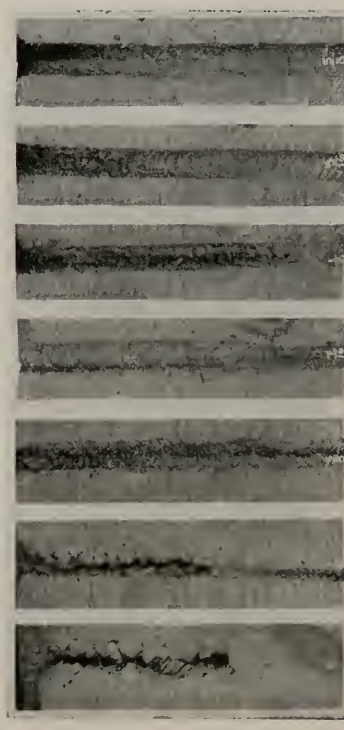
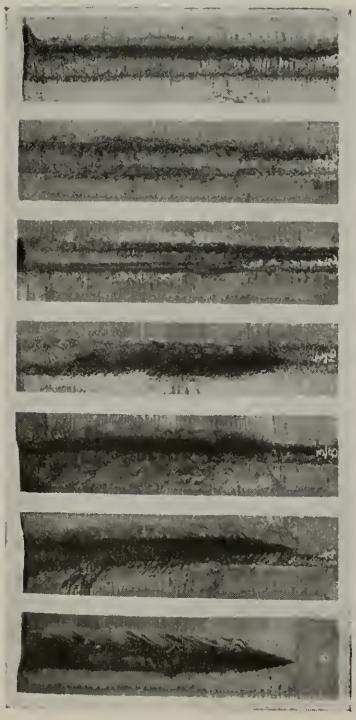


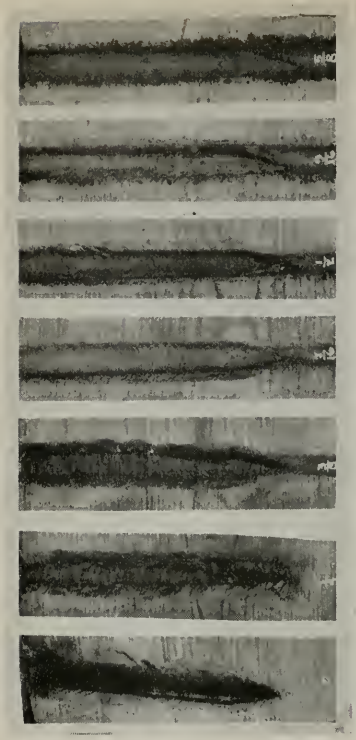
FIG. 19.—Wood fiber distortion in New Mexico pine, hewn ties, untreated. Numbers indicate size of bored hole.



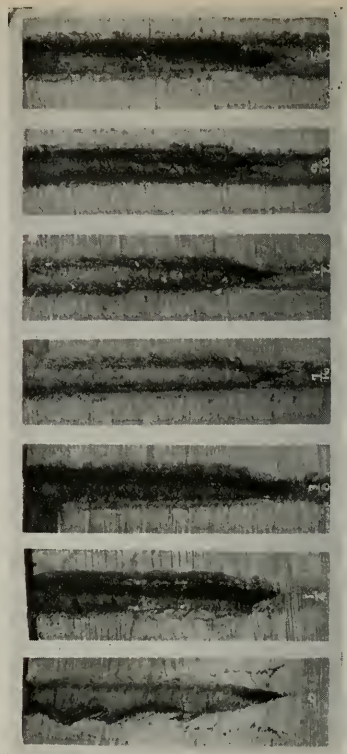
$\frac{9}{16}$-inch Spike

$\frac{5}{8}$-inch Spike

FIG. 21.—Wood fiber distortion in New Mexico pine, hewn ties, mixture treated. Numbers indicate size of bored hole.

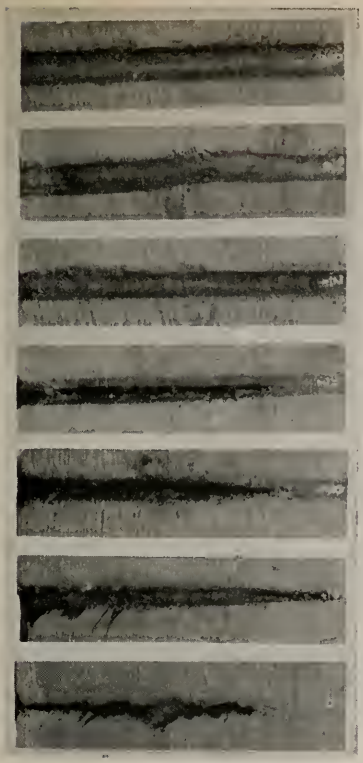


$\frac{9}{16}$-inch Spike

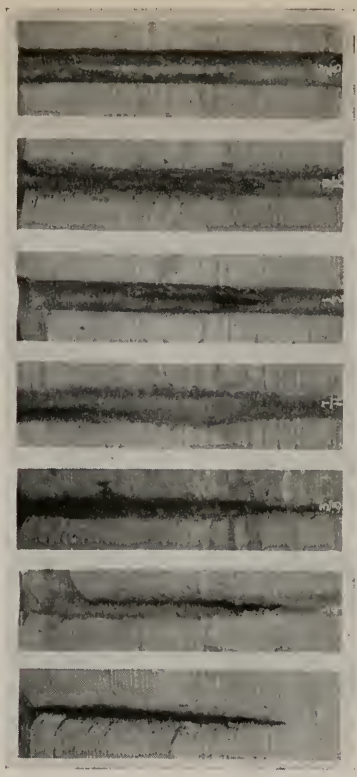


$\frac{5}{8}$-inch Spike

FIG. 20.—Wood fiber distortion in New Mexico pine, hewn ties, creosote treated. Numbers indicate size of bored hole.

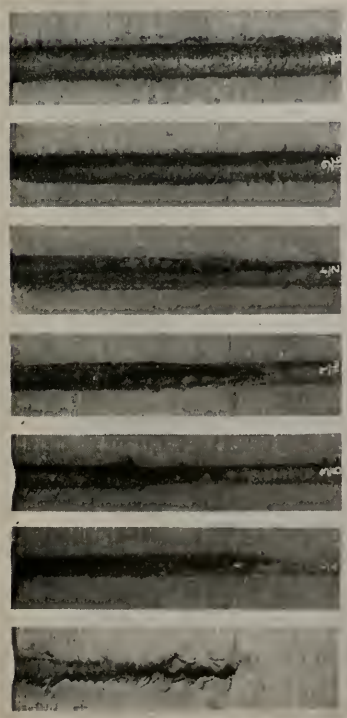


$\frac{9}{16}$-inch Spike

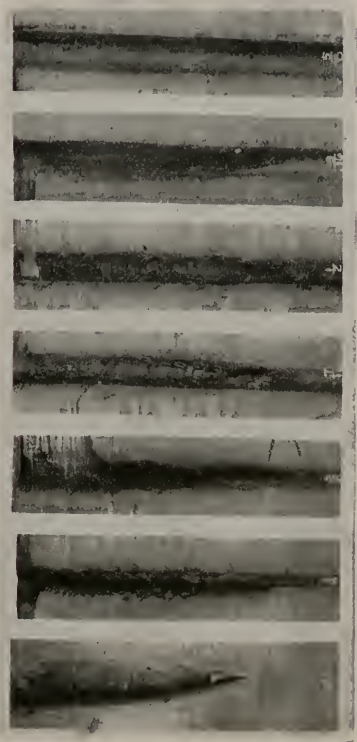


$\frac{9}{16}$-inch Spike

FIG. 22.—Wood fiber distortion in red spruce, hewn ties, untreated. Numbers indicate size of bored hole.

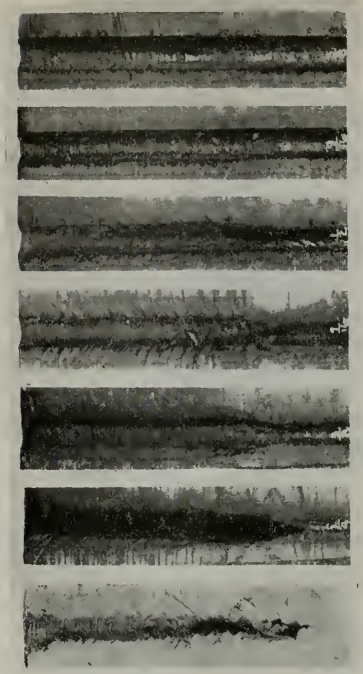


$\frac{9}{16}$-inch Spike

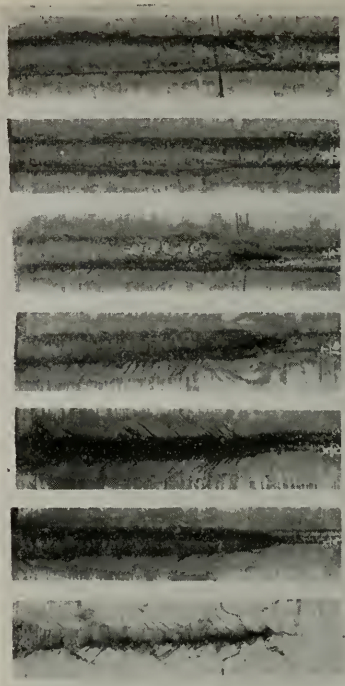


$\frac{9}{16}$-inch Spike

FIG. 23.—Wood fiber distortion in red spruce, hewn ties, creosote treated. Numbers indicate size of bored hole.

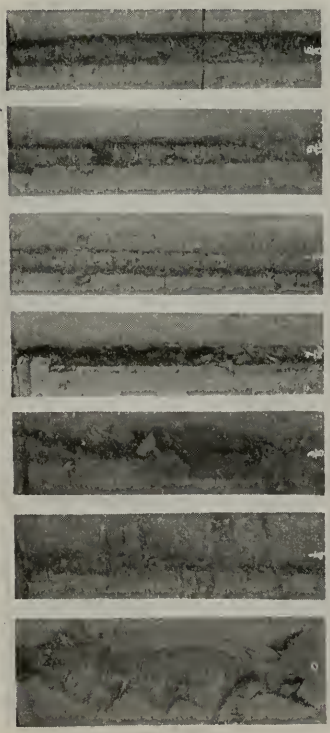


$\frac{9}{16}$-inch Spike

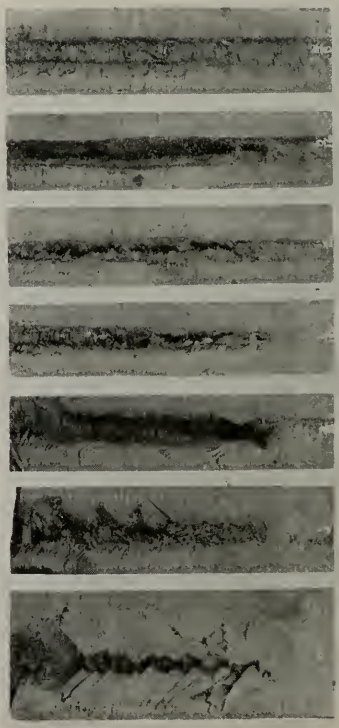


5/8-inch Spike

Fig. 24.—Wood fiber distortion in red spruce, hewn ties, mixture treated. Numbers indicate size of bored hole.

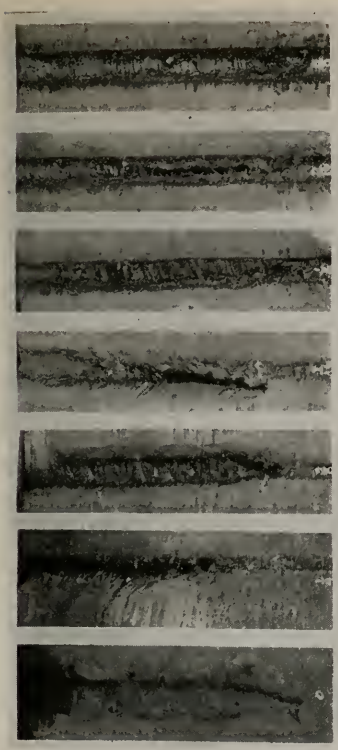


$\frac{9}{16}$-inch Spike

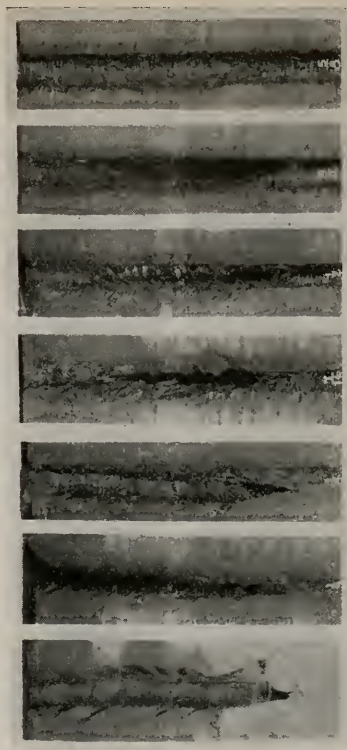


5/8-inch Spike

Fig. 25.—Wood fiber distortion in Engleman spruce, hewn ties, untreated. Numbers indicate size of bored hole.

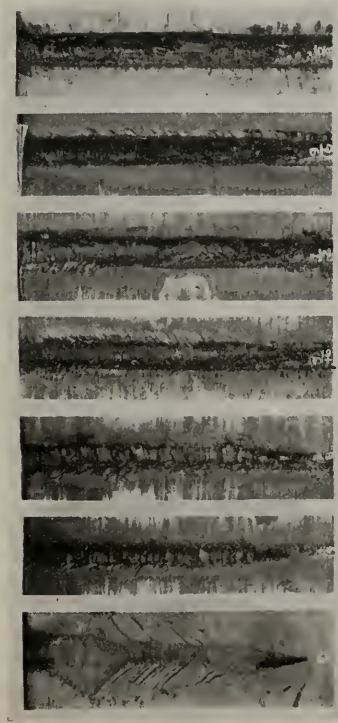


$\frac{9}{16}$-inch Spike

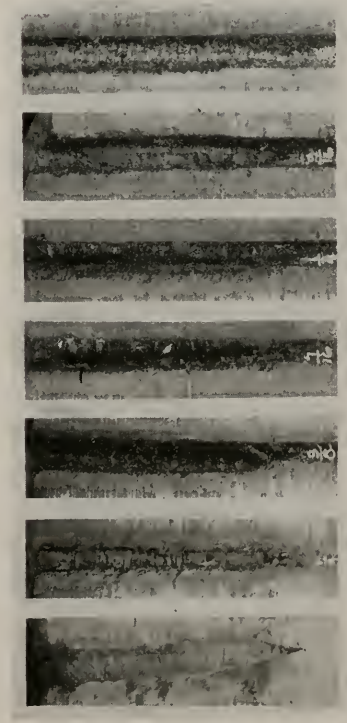


$\frac{5}{8}$-inch Spike

Fig. 26.—Wood fiber distortion in Engleman spruce, hewn ties, creosote treated. Numbers indicate size of bored hole.

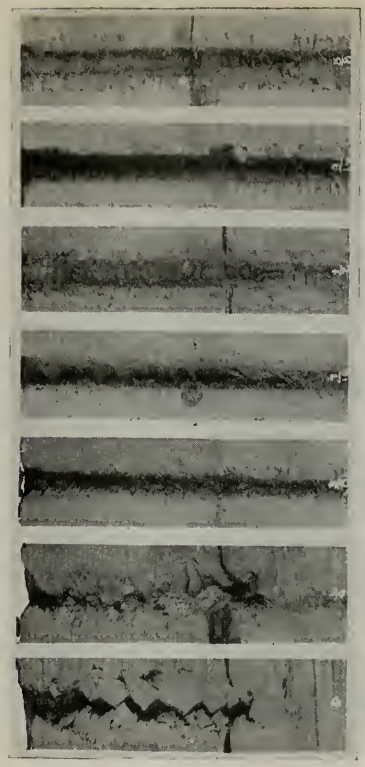


$\frac{9}{16}$-inch Spike

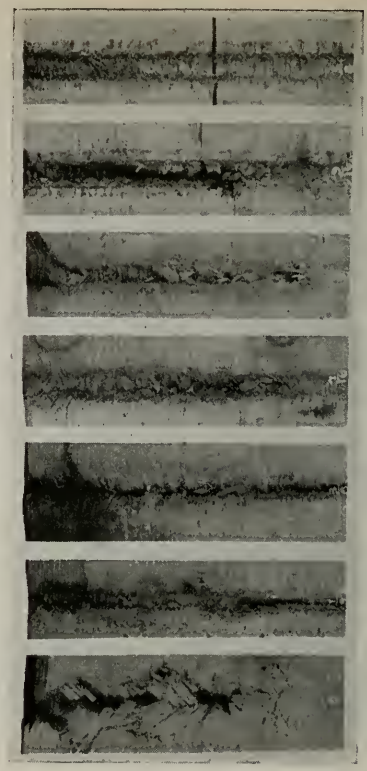


$\frac{5}{8}$-inch Spike

Fig. 27.—Wood fiber distortion in Engleman spruce, hewn ties, mixture treated. Numbers indicate size of bored hole.

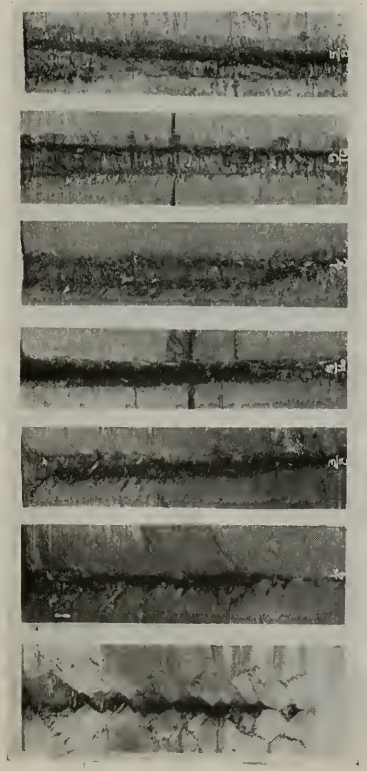


$\frac{9}{16}$-inch Spike

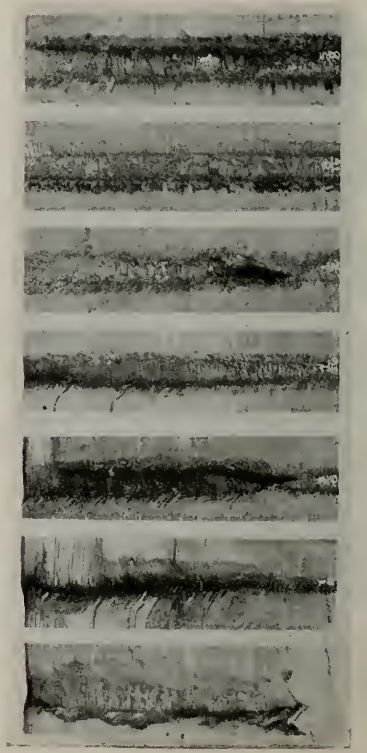


$\frac{5}{8}$-inch Spike

FIG. 28.—Wood fiber distortion in corkbark fir, hewn ties, untreated. Numbers indicate size of bored hole.

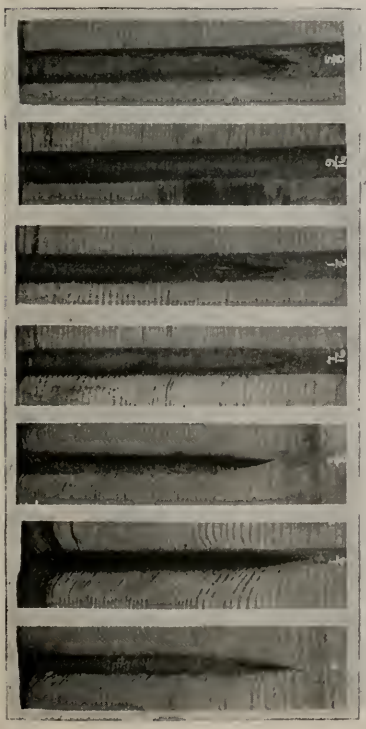


$\frac{9}{16}$-inch Spike

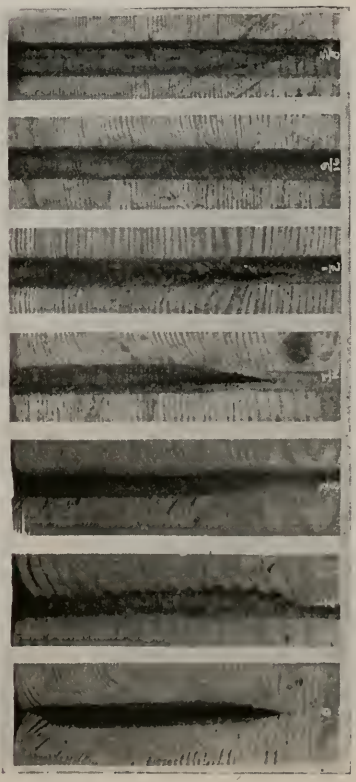


$\frac{5}{8}$-inch Spike

FIG. 29.—Wood fiber distortion in corkbark fir, hewn ties, creosote treated. Numbers indicate size of bored hole.

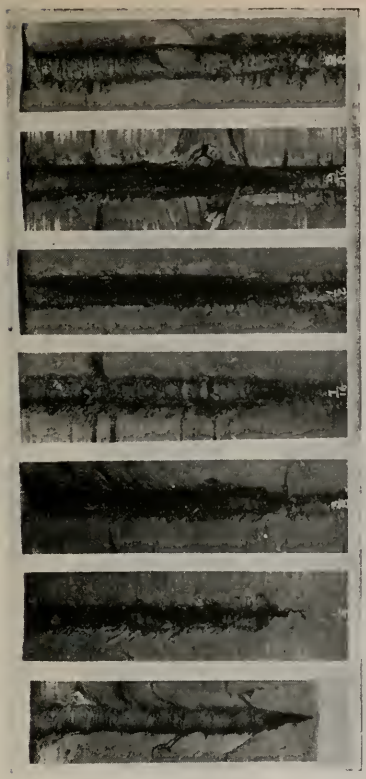


$\frac{13}{16}$-inch Spike

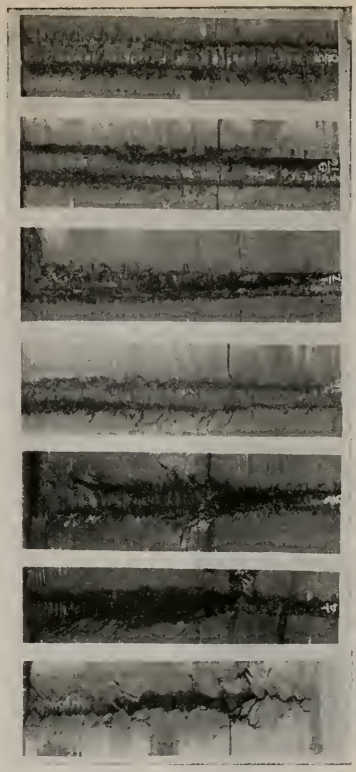


$\frac{5}{8}$-inch Spike

FIG. 31.—Wood fiber distortion in Douglas fir, sawn ties, untreated. Numbers indicate size of bored hole.

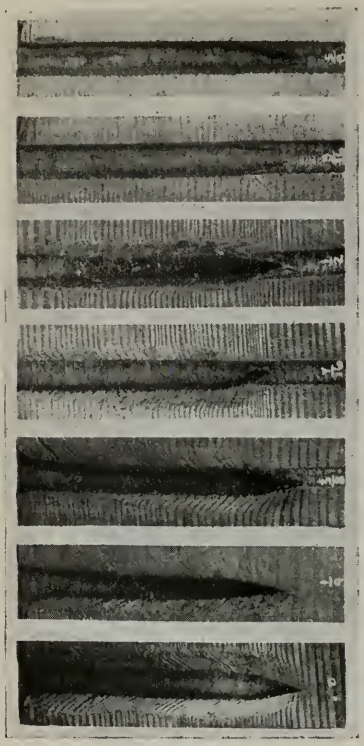


$\frac{13}{16}$-inch Spike

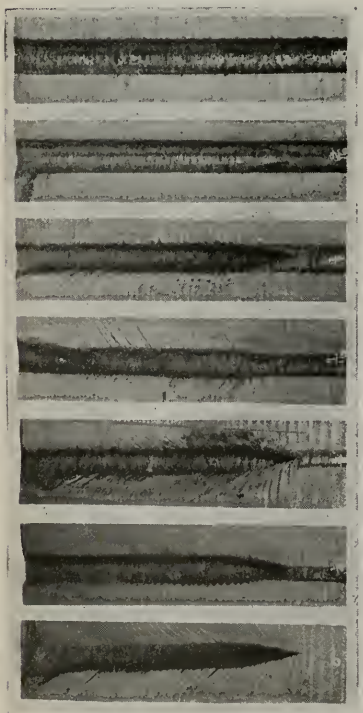


$\frac{5}{8}$-inch Spike

FIG. 30.—Wood fiber distortion in corkbark fir, hewn ties, mixture treated. Numbers indicate size of bored hole.

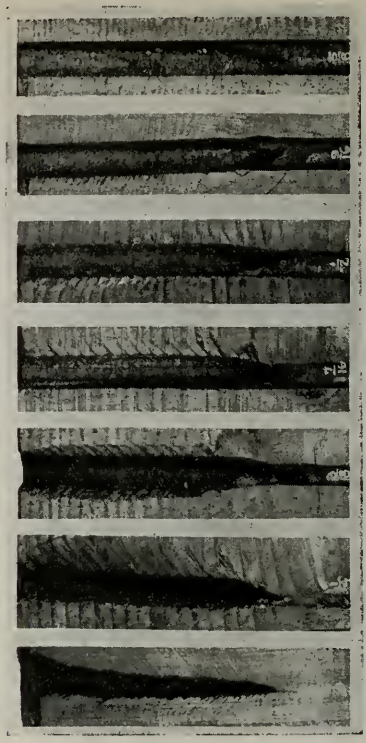


$\frac{9}{16}$-inch Spike

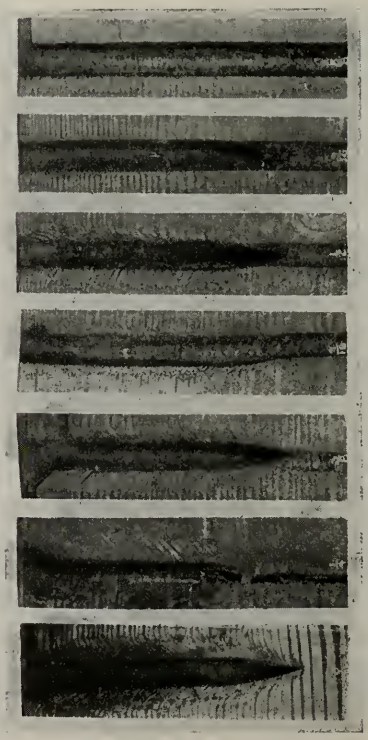


$\frac{9}{16}$-inch Spike

Fig. 33.—Wood fiber distortion in Douglas fir, sawn ties, treated. Numbers indicate size of bored hole.



$\frac{5}{8}$-inch Spike



$\frac{5}{8}$-inch Spike

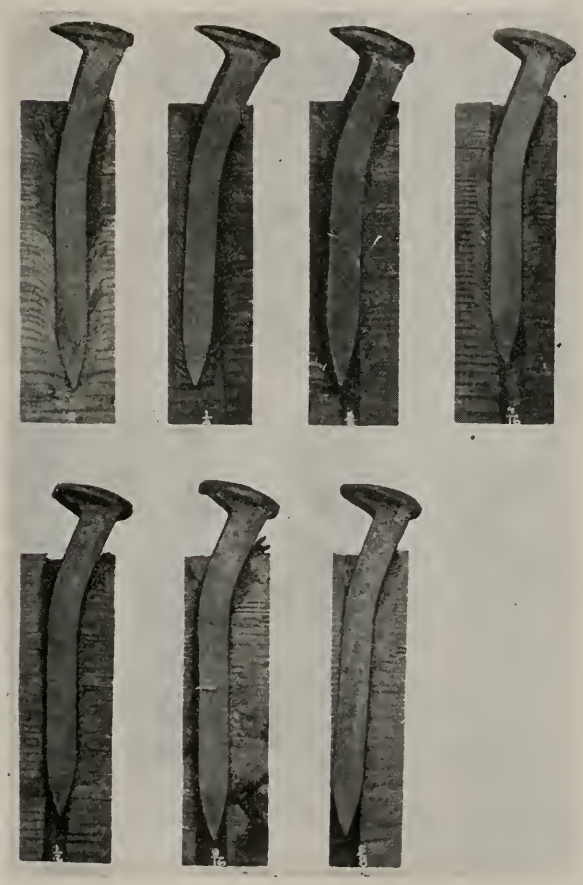
Fig. 32.—Wood fiber distortion in Douglas fir, sawn ties, creosote treated. Numbers indicate size of bored hole.

$\frac{9}{16}$-inch Spike

Fig. 34.—Distortion of spike and wood fiber in side thrust in New Mexico pine, hewn ties, mixture treated. Numbers indicate size of bored hole.

⅝-inch Spike

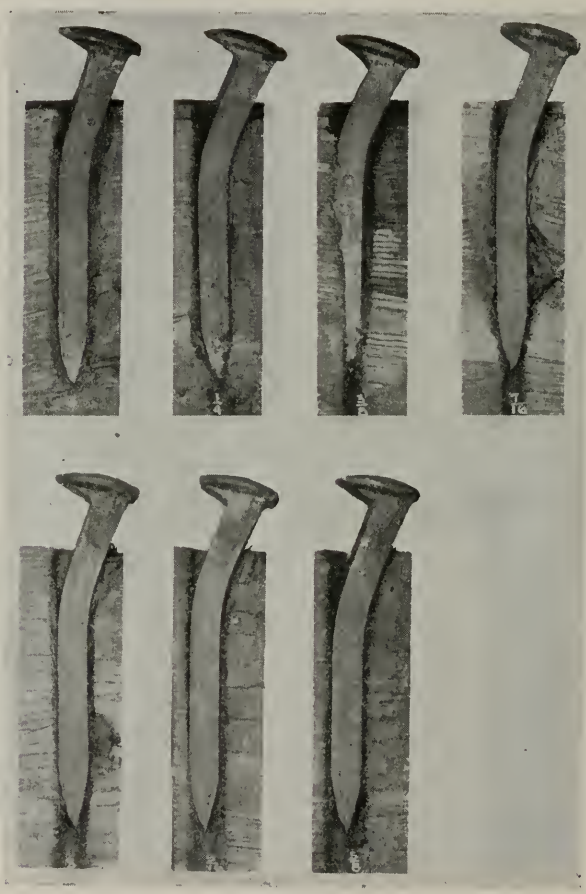
Fig. 35.—Distortion of spike and wood fiber in side thrust, in Douglas fir, sawn ties, creosote treated. Numbers indicate size of bored hole.



$\frac{9}{16}$-inch Spike

FIG. 36.—Distortion of spike and wood fiber in side thrust in Douglas fir, sawn ties, creosote treated. Numbers indicate size of bored hole.

A



⅝-inch Spike

Fig. 37.—Distortion of spike in wood fiber in side thrust in New Mexico pine, hewn ties, creosote treated. Numbers indicate size of bored hole.

$\frac{9}{16}$-inch Spike

FIG. 38.—Distortion of spike and wood fiber in side thrust in New Mexico pine, hewn ties, mixture treated. Numbers indicate size of bored holes.

5⅝-inch Spike

Fig. 39.—Distortion of spike and wood fiber in side thrust in wide ring loblolly pine, hewn ties, creosote treated. Numbers indicate size of bored holes.

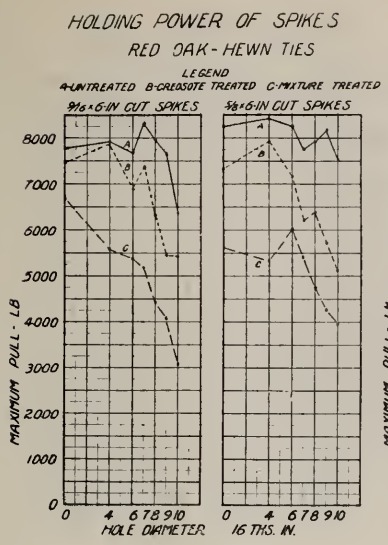


Fig. 40

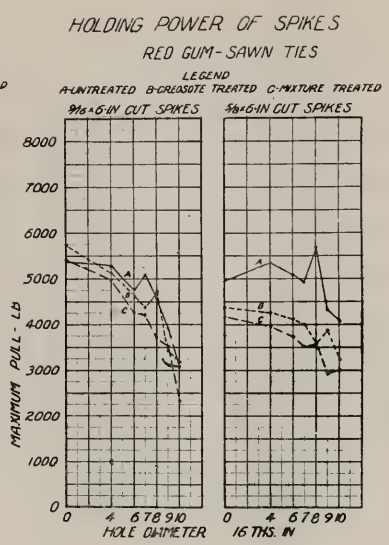


Fig. 41

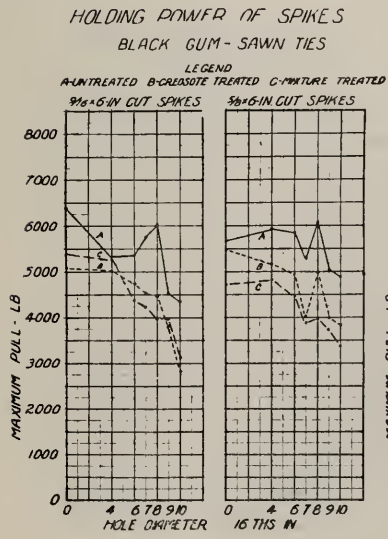


Fig. 42

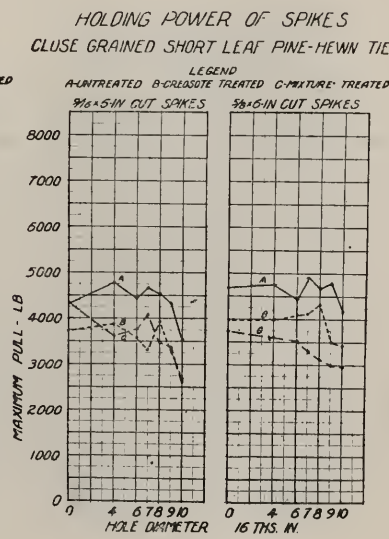


Fig. 43

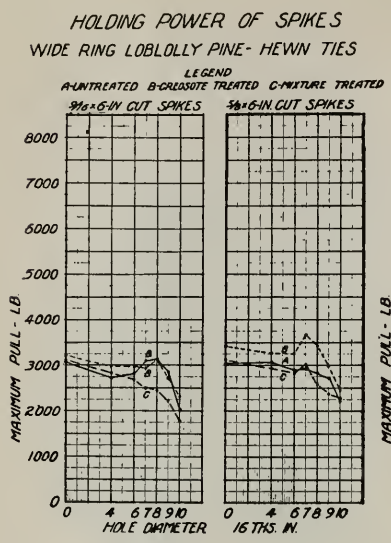


Fig. 44

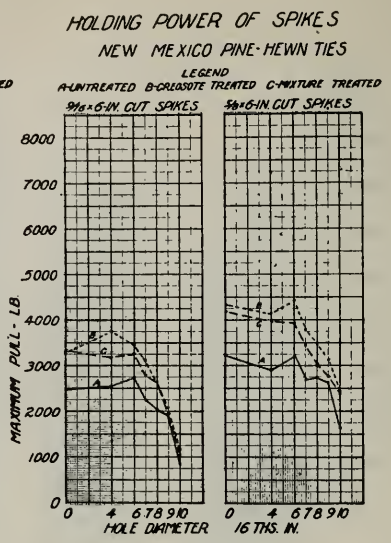


Fig. 45

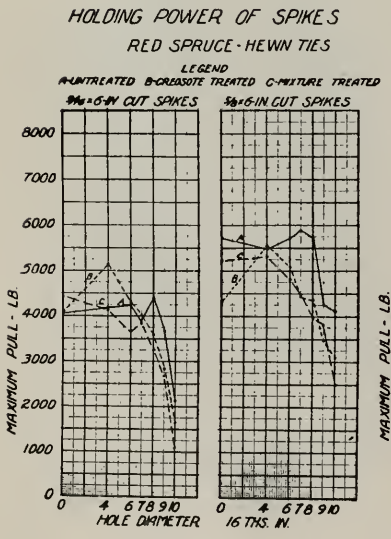


Fig. 46

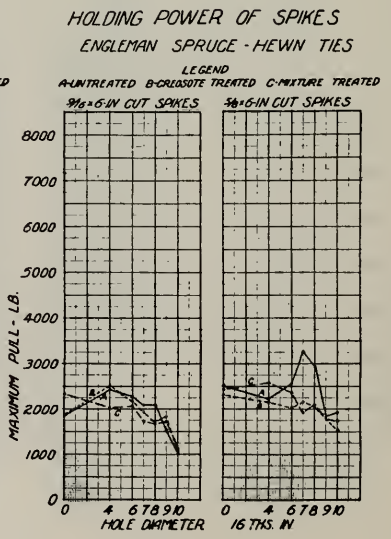


Fig. 47

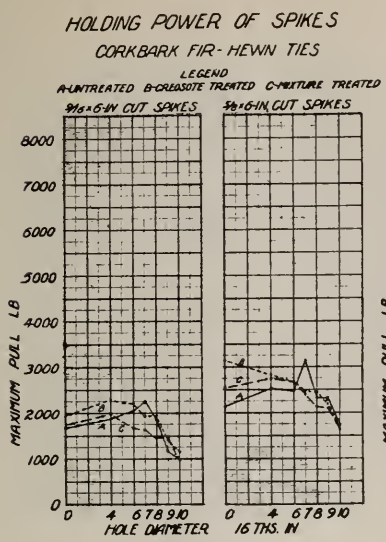


Fig. 48

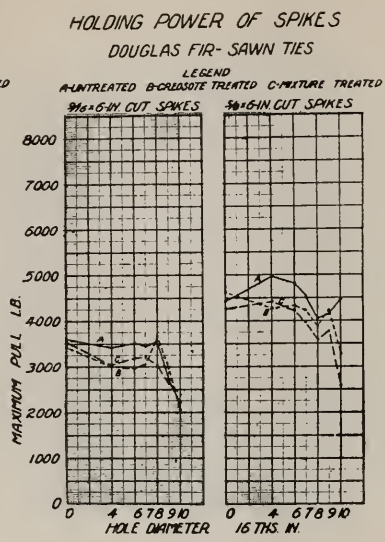


Fig. 49

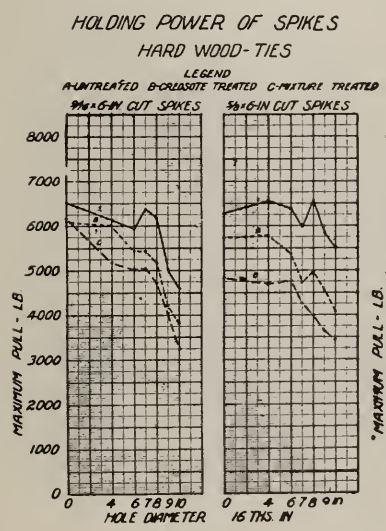


Fig. 50

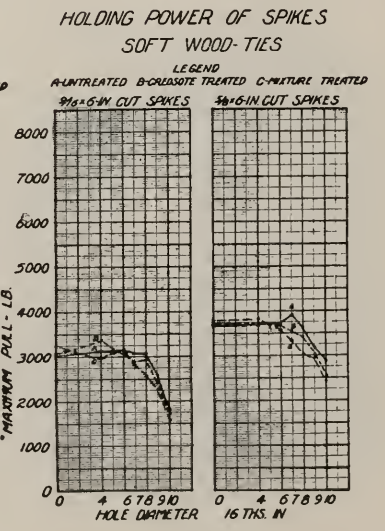


Fig. 51

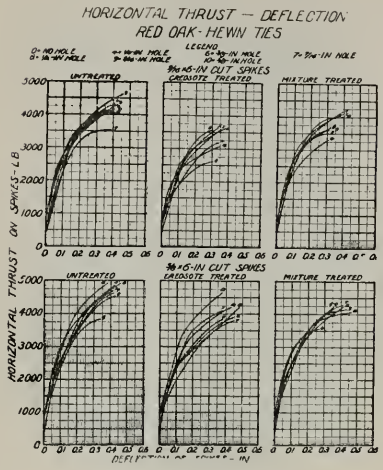


Fig. 52

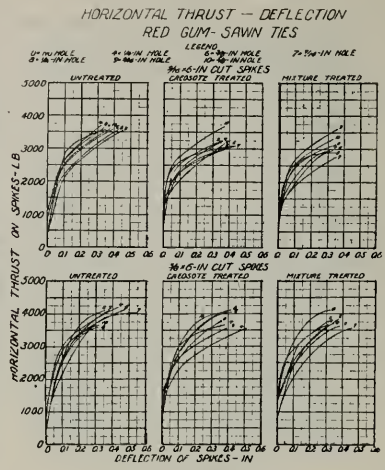


Fig. 53

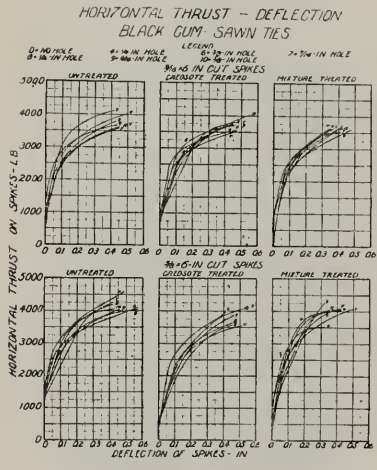


Fig. 54

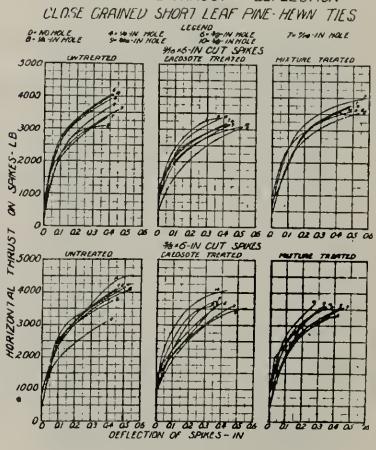


Fig. 55

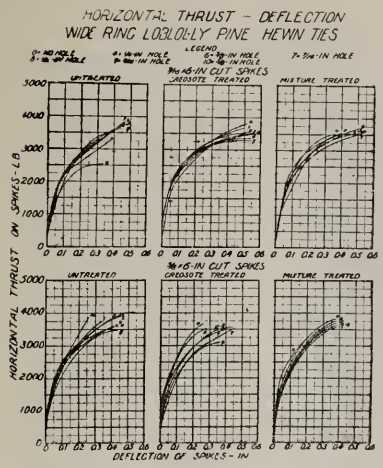


Fig. 56

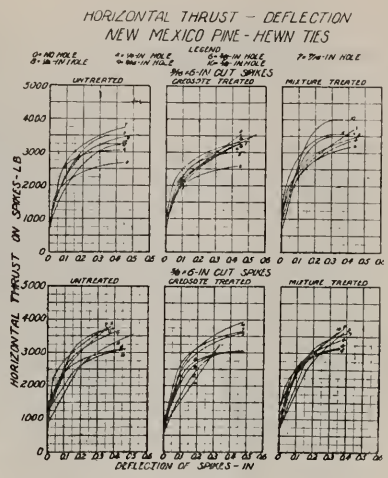


Fig. 57

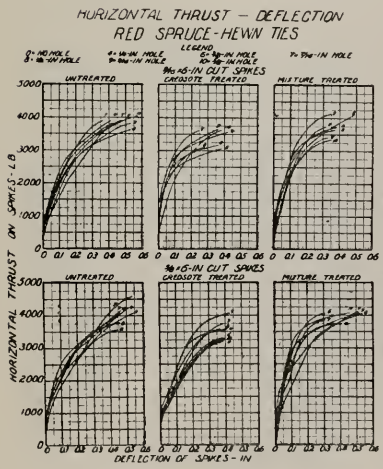


Fig. 58

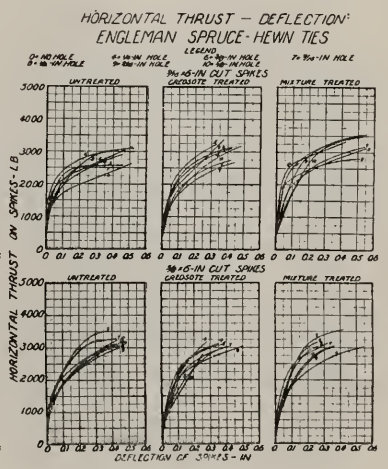


Fig. 59

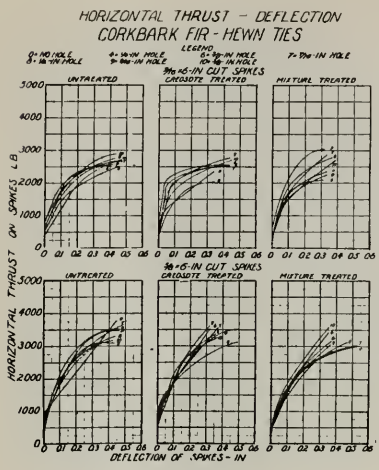


Fig. 60

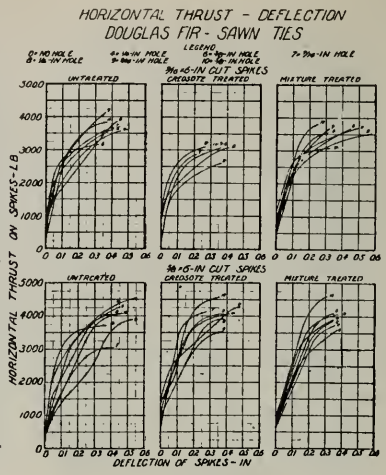


Fig. 61

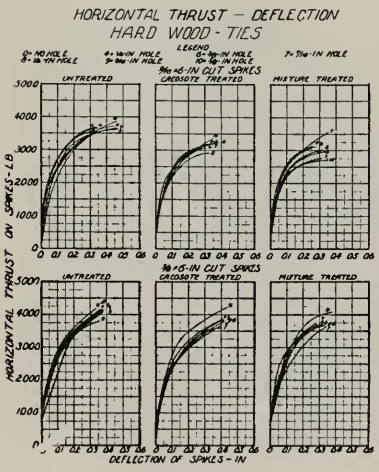


Fig. 62

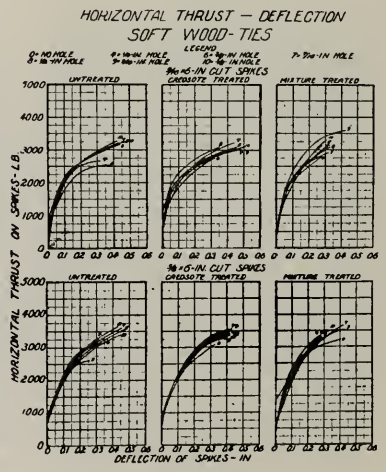


Fig. 63

TABLE 2.

HOLDING POWER OF SPIKES IN HARD WOODS

Kind of Wood	Pull to Start Spikes, lb. No Hole	1/4-in. Hole	3/8-in. Hole	7/16-in. Hole	1/2-in. Hole	9/16-in. Hole	5/8-in. Hole
9/16 by 6-in. Cut Spikes							
Untreated							
Red Oak	7790	7920	7680	8330	7970	7650	6360
Red Gum	5380	5290	4760	5100	4580	3920	3080
Black Gum	6380	5280	5370	5750	6010	4530	4350
Average	6520	6160	5940	6390	6190	5030	4600
Creosote Treated							
Red Oak	7460	7870	6890	7380	6310	5450	5440
Red Gum	5730	5140	4630	4390	4700	3410	3160
Black Gum	5090	5010	4730	4530	4480	3800	2830
Average	6090	6010	5420	5430	5160	4220	3810
Mixture Treated							
Red Oak	6680	5580	5380	5190	4430	4090	3060
Red Gum	5410	4980	4270	4200	3700	3520	2330
Black Gum	6380	5280	5370	5750	6010	4530	4350
Average	6160	5280	5010	5050	4710	4050	3250
5/8 by 6-in. Cut Spikes							
Untreated							
Red Oak	8250	8410	8250	7750	7920	8190	7530
Red Gum	4950	5330	5090	4920	5700	4320	4070
Black Gum	5670	5930	5850	5290	6060	5030	4890
Average	6290	6560	6400	5990	6560	5850	5500
Creosote Treated							
Red Oak	7340	7920	7160	6200	6380	5730	5120
Red Gum	4360	4270	4120	4000	3580	3890	3230
Black Gum	5490	5160	4940	4010	4960	3990	3820
Average	5730	5780	5370	4740	4970	4540	4060
Mixture Treated							
Red Oak	5610	5330	6090	5410	4750	4280	3960
Red Gum	4170	3960	3730	3510	3520	2920	3000
Black	4710	4810	4460	3870	3980	3740	3390
Average	4830	4700	4760	4260	4000	3640	3450

TABLE 3.

HOLDING POWER OF SPIKES IN SOFT WOOD

Kind of Wood	Pull to Start Spikes, lb.						
	No Hole	1/4-in. Hole	3/8-in. Hole	7/16-in. Hole	1/2-in. Hole	9/16-in. Hole	5/8-in. Hole
	9/16 by 6-in. Cut Spikes						
Untreated.							
Short Leaf Pine	4310	4790	4440	4660	4550	4340	3540
Loblolly Pine	3080	2710	2820	3100	3130	2850	2020
New Mexico Pine	2490	2530	2740	2250	2030	1920	840
Red Spruce	4070	4170	4240	3870	4400	3670	2140
Engleman Spruce	1840	2430	2290	2080	2090	1530	1010
Corkbark Fir	1690	1870	2050	2250	1850	1170	960
Douglas Fir	3600	3410	3510	3450	3560	2730	2210
Average	3010	3130	3150	3090	3090	2600	1810
Creosote Treated.							
Short Leaf Pine	3730	3870	3590	3310	3930	3290	2680
Loblolly Pine	3210	2990	2970	2940	3120	3730	2310
New Mexico Pine	3260	3740	3450	3110	2650	2080	1160
Red Spruce	4100	5140	4300	4040	3590	2840	1620
Engleman Spruce	1880	2520	2170	1930	1720	1790	1060
Corkbark Fir	1940	2290	2200	1910	1920	1410	1140
Douglas Fir	3430	3000	2970	3050	3650	2890	2050
Average	3080	3360	3090	2900	2940	2430	1710
Mixture Treated.							
Short Leaf Pine	4330	3610	5750	4070	3480	3370	2620
Loblolly Pine	3100	2830	2690	2500	2440	2220	1780
New Mexico Pine	3310	3170	3250	2790	2620	1960	1050
Red Spruce	4440	4130	3650	3850	3250	2680	1070
Engleman Spruce	2320	2030	2070	1730	1680	1710	1110
Corkbark Fir	1730	1990	1660	1620	1450	1460	980
Douglas Fir	3550	3040	3200	3230	3040	2620	2380
Average	3250	2970	3180	2830	2570	2290	1570

TABLE A.

HOLDING POWER OF SPIKES IN SOFT WOOD

Kind of Wood	Pull to Start Spikes, lb. No Hole	1/4-in. Hole	3/8-in. Hole	7/16-in. Hole	1/2-in. Hole	9/16-in. Hole	5/8-in. Hole
	5/8 by 6-in. Cut Spikes						
Untreated							
Short Leaf Pine	4680	4750	4430	4910	4670	4790	4170
Loblolly Pine	3040	3070	2890	2920	2830	2720	2210
New Mexico Pine	3220	2910	3220	2690	2730	2140	1640
Red Spruce	5700	5470	5710	5880	5730	4250	4110
Engleman Spruce	2520	2210	2560	3280	2930	1850	1940
Corkbark Fir	2140	2520	2480	3130	2320	2340	1710
Douglas Fir	4440	4990	4840	4540	4060	4140	4480
Average	3680	3700	3730	3910	3610	3180	2890
Creosote Treated							
Short Leaf Pine	3970	3990	4090	4120	4320	3500	3420
Loblolly Pine	3420	3270	3250	3670	3410	2970	2450
New Mexico Pine	4330	4140	4430	3780	3460	3120	2430
Red Spruce	4300	5550	5090	4430	4350	3470	3100
Engleman Spruce	2310	2150	2030	2150	2050	1810	1540
Corkbark Fir	3130	2830	2650	2480	2440	2190	1620
Douglas Fir	4610	4290	4330	4230	3870	4240	3280
Average	3720	3750	3690	3550	3410	3040	2550
Mixture Treated							
Short Leaf Pine	4340	4900	4350	4200	3940	3950	3900
Loblolly Pine	3120	2920	2820	3010	2590	2390	2290
New Mexico Pine	4180	3970	3930	3450	3010	2750	2360
Red Spruce	5190	5300	4800	4400	3950	3800	2500
Engleman Spruce	2430	2580	2350	1910	2090	1800	1740
Corkbark Fir	2550	2740	2630	2400	2110	2190	1640
Douglas Fir	4270	4410	4210	3980	3580	3790	2580
Average	3800	3830	3580	3350	3040	2950	2430

TABLE 5

THRUST RESISTANCE OF SPIKES

	Thrust and Deflection at Yield Point:						
	No Hole	1/4-in. Hole	3/8-in. Hole	7/16-in. Hole	1/2-in. Hole	9/16-in. Hole	5/8-in Hole
Hard Wood Ties							
9/16 by 6-in. Cut Spikes							
Untreated:							
Thrust, lb.	3000	3000	3050	2950	2800	2950	2800
Deflection, in.	0.14	0.15	0.15	0.15	0.15	0.20	0.14
Creosote Treated:							
Thrust, lb.	2500	2450	2350	2450	2600	2650	2400
Deflection, in.	0.12	0.13	0.13	0.13	0.14	0.13	0.10
Mixture Treated:							
Thrust, lb.	2550	2350	2500	2200	2650	2550	2300
Deflection, in.	0.10	0.11	0.13	0.10	0.12	0.11	0.11
5/8 by 6-in. Cut Spikes							
Untreated:							
Thrust, lb.	3150	3250	3200	3300	3150	3050	3250
Deflection, in.	0.14	0.14	0.16	0.20	0.14	0.15	0.14
Creosote Treated:							
Thrust, lb.	2400	2550	2750	3000	2750	2800	3200
Deflection, in.	0.10	0.13	0.16	0.18	0.16	0.15	0.15
Mixture Treated:							
Thrust, lb.	2700	3000	2950	2750	3100	3050	3550
Deflection, in.	0.08	0.13	0.14	0.15	0.16	0.16	0.19
Soft Wood Ties							
9/16 by 6-in. Cut Spikes							
Untreated:							
Thrust, lb.	2250	2250	2300	2300	2300	2300	2400
Deflection, in.	0.18	0.14	0.12	0.13	0.14	0.14	0.16
Creosote Treated:							
Thrust, lb.	2000	2400	2200	2100	2400	2350	2250
Deflection, in.	0.12	0.17	0.14	0.10	0.12	0.15	0.13
Mixture Treated:							
Thrust, lb.	1950	1950	2050	2300	2150	2850	2150
Deflection, in.	0.08	0.08	0.09	0.13	0.18	0.17	0.12
5/8 by 6-in. Cut Spikes							
Untreated:							
Thrust, lb.	2300	2700	2700	2600	2750	2550	2550
Deflection, in.	0.13	0.16	0.20	0.18	0.20	0.15	0.19
Creosote Treated:							
Thrust, lb.	2450	2750	2650	2900	2700	2800	2700
Deflection, in.	0.12	0.20	0.19	0.21	0.20	0.18	0.16
Mixture Treated:							
Thrust, lb.	2800	2150	1850	2350	2650	2700	2800
Deflection, in.	0.20	0.08	0.07	0.14	0.20	0.19	0.16

TABLE 6.

THRUST RESISTANCE OF SPIKES.

	Thrust and Deflection at Yield Point						
	No Hole	1/4-in. Hole	3/8-in. Hole	7/16-in. Hole	1/2-in. Hole	9/16-in. Hole	5/8-in. Hole
Average of all treatments on Hard Wood Ties							
9/16 by 6-in. Cut Spikes							
Thrust, lb.	2630	2600	2630	2530	2680	2720	2500
Deflection, in.	0.12	0.13	0.14	0.13	0.14	0.15	0.12
5/8 by 6-in. Cut Spikes							
Thrust, lb.	2750	2930	2970	3020	3000	2970	3300
Deflection, in.	0.11	0.13	0.15	0.18	0.15	0.15	0.16
Average of all treatments of Soft Wood Ties							
9/16 by 6-in. Cut Spikes							
Thrust, lb.	2100	2200	2180	2230	2280	2500	2270
Deflection, in.	0.13	0.13	0.12	0.12	0.15	0.15	0.14
5/8 by 6-in. Cut Spikes							
Thrust, lb.	2520	2530	2400	2610	2700	2680	2680
Deflection, in.	0.15	0.15	0.15	0.18	0.20	0.17	0.17

one time and these spikes pulled before driving spikes into the ½-in., $\frac{7}{16}$-in. and no hole. A pulling speed of 0.2 in. per minute was used to start the spikes.

In determining the resistance to horizontal thrust, the set-up was used as shown in the photograph, Fig. 3. The tie was placed on end on the fixed head of the testing machine and a load applied to the throat of the spike through a ¾-in. plate attached to the moving head. Deflection of the spike was measured by an extensometer attached to the moving head and connected with a wire to a nail driven in the tie. With this arrangement, all movements between the tie and the fixed head were eliminated from the extensometer reading. An initial load of 200 lb. was applied and the extensometer set at zero. Readings were taken at 500-lb. increments of load. Three ties were selected for the test having one of each type of grain. Spikes were driven to gage as in the pull test.

After pulling the spikes, the ties were sawed and split through the spike hole so as to note the effect of the spike in the fiber. Photographs of representative fiber deformation for the untreated, creosote treated and mixture treated wood are shown in Fig. 4 to 33, inclusive.

After the side-thrust test, a number of the ties were sawed and split in order to show the character of the deformation of both wood and spike. Photographs of these cross-sections are shown in Fig. 34 to 39, inclusive.

Discussion

In driving the spikes for this test, it was difficult to make the spikes follow the holes, particularly in the ¼-in. and ⅜-in. holes. In the larger holes, the spikes had a tendency to twist while being driven. Due to the arrangement of the holes, very few splits were encountered. Spikes were not driven in holes bored through splits or visible knots. In all woods, the starting load was the maximum load.

In analyzing the data on the resistance to vertical pull, a series of graphs were made in which maximum pull was plotted against the size of holes as shown in Fig. 40 to 49, inclusive. Curves are drawn for untreated, creosote treated and mixture treated ties, using both $\frac{9}{16}$ and ⅝ in. spikes. A study of these curves shows the untreated wood to have a more defined curve with the more definite placing of the correct size of hole to give maximum pull. The curve for the mixture treated wood in most cases is the more indefinite as to the correct size of hole to bore.

The lubricating effect of the treatments reduces the holding power of the spike in most cases excepting New Mexico pine and loblolly pine. In these woods, the creosote treatment increases the holding power of the spike, probably due to a toughening of the brittle fibers of these woods.

As it is considered impractical to determine upon the correct size of hole for each wood, the woods were grouped into hard and soft classes. The summary of the data for the three hard woods used in this test, viz., red oak, red gum, and black gum, is given in Table 2, and the curves plotted from these data are shown in Fig. 50. The remaining seven woods used were classified as softwoods and the summary of these data is given in Tables 3 and 4 with the accompanying curves in Fig. 51. Due to the difficulty in making the spikes follow the ¼-in. and ⅜-in. holes, these sizes of holes are deemed too small for practical use. A study of the data with this in mind shows the correct size of holes for maximum pull in hard woods to be $\frac{7}{16}$-in. for the $\frac{9}{16}$-in. spikes and ½-in. for the ⅝-in. spikes. For the softwoods, $\frac{7}{16}$-in. diameter gives the maximum pull for both $\frac{9}{16}$-in. and ⅝-in. spikes.

Analysis of the data on resistance to horizontal thrust required a series of graphs in which horizontal thrust was plotted against deflection, as shown in Fig. 52 to 61, inclusive. This gave a stress-strain curve for each size

hole from which the load at yield point with its accompanying deflection was determined.

A study of these data shows no great variance between load and deflection with no hole, and load and deflection when spike is driven into 5/8-in. hole. As in the case of the vertical pull, the woods were classified and average stress-strain curves drawn for the hardwoods and the softwoods, as shown in Fig. 62 and 63. Table 4 shows results of this grouping. Averaging the untreated, creosoted treated and mixture treated woods, it is found that for the 9/16-in. spikes, the 9/16-in. hole has the highest load at yield point for both hard and soft woods. For the 5/8-in. spikes, the 5/8-in. hole takes the higher load, for the hardwoods, and there is practically no difference with the 1/2, 9/16, and 5/8 in. holes for the softwoods, as shown by the data in Table 5. However, there is such small variation between the load at yield point for the various sizes of holes that for all practical purposes the size of hole can be governed by the size of holes giving the highest holding power to the spikes in vertical pull.

A study of the distortion of wood fibers in the various kinds of wood, Fig. 4 to 33, shows the deformation in the red oak and red gum to be very regular and smooth. The fibers have a tendency to straighten after the spike is withdrawn. The deformation in the black gum is similar to that in the red gum, but not so regular, and there are considerable broken fibers where spikes were driven with no holes.

The deformation in the close-grained shortleaf pine is rather irregular with short bends and many broken fibers in the coarse grained wood. In the loblolly pine the fibers are torn, crushed and broken with very little bending. Deformation in the New Mexico pine and red spruce is very similar. Both have short bending of the fibers close to the spike. The fibers are crushed and broken, particularly in the New Mexico pine. In the Engleman spruce and corkbark fir there is very little bending of the fibers, but the wood is torn and broken even where the spikes were driven in the smaller sizes of drilled holes. The fiber was so badly torn that it was difficult to secure a representative cross-section of the hole. In Douglas fir the deformation is very regular with long bends and no broken fibers.

A comparison of holding power of the spikes and the deformation of wood fibers shows the lowest holding power in the woods having the most torn and broken fibers. Lowest holding power is in Engleman spruce and corkbark fir and the highest in red oak.

A study of the distortion of wood fibers in the various sizes of holes shows the disturbance of fibers to be much less where spikes were driven in holes 7/16 in. diameter or larger. It was also noticed that treatment is not nearly so thorough in case of the 1/4-in. and 3/8-in. drilled holes as in the larger holes.

Cross-sections of the wood and spike after thrust test, Fig. 34 to 39, inclusive, show that there was practically no distortion of wood or spike due to horizontal thrust deeper than one-inch below the surface of the tie.

It will be noted that the tests made by Mr. Chapman involve more than 5000 individual tests. Particular attention is called to the photographs showing damage to the wood fiber, which is greater where no holes are bored or where the holes are too small. The benefit from pre-boring is, therefore, not only in the added resistance to withdrawal and side thrust, but also that due to the greater freedom from damaged wood fiber and the resulting rapid deterioration of the tie.

One feature developed by these tests which should have further attention is the design of the point of the spike. It was found that the ordi-

nary chisel pointed spike does not follow the hole as well as desirable, and the Committee is, therefore, recommending this subject for further investigation.

Tests so far would indicate that a modified chisel point may be desirable, in which the chisel edge is slightly less than the diameter of the hole. Such a spike will not only follow the bored hole but can be used where holes have not been bored, and when spikes must be driven into tie plugs.

While the Committee has not considered the question of the size of spike as included in its assignment, attention is called to the fact that these tests would indicate little, if any, advantage from the 5/8-in. spike as compared to the 9/16-in. This more particularly as regards withdrawal tests.

It is the customary American practice to bore the holes entirely through the tie. It is the understanding of the Committee that it is common European practice not to bore entirely through the tie. The only suggestion coming to the attention of the Committee which would indicate that holes should not be bored entirely through the tie is from a direct current electric line having covered track. Under these conditions, it was found after a few years that the spikes were badly corroded, due to electrolysis, the theory being that a comparatively low resistance path was formed for the return current from the bottom of the spikes through the holes to the sub-soil. This, however, is a condition peculiar to the street railways. No such trouble has been noticed on electrically operated steam railways so far as the Committee is aware.

Conclusions

(1) The less the distortion of the wood, the greater the resistance of the spike to horizontal thrust.

(2) There is the least damage to the fiber when the largest hole is used.

(3) For hardwood ties, the greatest resistance to withdrawal results with a hole slightly smaller than the largest.

(4) The 1/4-in. and 3/8-in. holes are too small for use with chisel pointed spikes.

(5) The chisel pointed spike is unsatisfactory for driving into bored holes because of the tendency of the sharp corners to lead the spike away from the hole.

Recommendations

(1) That holes for cut spikes in hardwoods be 1/16-in. smaller than the diameter of the spike.

(2) That holes for cut spikes in softwoods be 1/8-in. smaller than the diameter of the spike.

Appendix C

(5) MAKE RECOMMENDATIONS AS TO RENEWAL OF SWITCH TIES

W. C. Bolin, Chairman, Sub-Committee; M. S. Blaiklock, P. B. Jeffries, J. E. King, J. S. Ruff, R. W. Willis.

Renewal of switch ties out of face (complete set) usually takes place when 50 per cent or more of the ties are unserviceable. The remaining ties would have remaining lives of from one to six or seven years approximately. Considering those having a remaining life of from one to three years the tendency would be to scrap rather than store them for future use. If they were to be used again, a 12-foot tie may have to be used instead of a 10-foot tie on account of not having complete sets. In this case (in order to have a uniform appearance, which is desirable) the 12-foot ties would have to be cut shorter and re-adzed which would mean a loss of material and an additional labor cost.

Owing to the fact that the ties under the switch point and frog wear out sooner than the others, there would be a surplus of intermediate ties salvaged when the out of face (complete set) method of renewals is used which would cause a considerable amount of the loss mentioned above.

To show further loss when the out of face (complete set) renewal method is used, consider the switch ties in a No. 10 turnout, having sixteen years average life, 10 per cent will require renewal each year, beginning with the eleventh year and completing with the twentieth year.

Under this method needed renewals might be postponed until the end of the fifteenth year, when 50 per cent of the ties would be unserviceable. The remaining 5 per cent of the ties having a total of 99 tie years life yet remaining would then be taken out. The average tie for the set would cost $6.30; the annual cost would be $0.64; the loss in material at each renewal would be 99 times $0.64 = $63.40.

The labor cost of applying the average tie of this No. 10 set is $0.70 by out of face method; by the method of individual renewal, it is $1.00 per tie. The saving in labor per renewal of the set is $1.00 less $0.70, or $0.30 multiplied 66 times = $19.80. The loss in both labor and material by the out of face method is $63.40 less $19.80, or $43.60.

From the standpoint of economy, out of 28 railroads canvassed, 8 recommended the out of face method, 12 recommended the individual method, 8 were conditional.

In regard to safety, the tendency in renewing out of face is to let conditions get bad enough to justify it, which is contrary to safe practice.

In general the individual method is the best economically, because of the saving on material and labor, and better from a safety standpoint, and because of the more uniform maintenance it provides an easy riding track at all times.

Appendix D

(6) SUBSTITUTE TIES

S. B. Clement, Chairman, Sub-Committee; W. W. Wysor.

Baltimore & Ohio Railroad

Reported by Earl Stimson, Chief Engineer Maintenance.
Date—June 21, 1927.
Kind—Wyckoff.

During July, 1927, the installation of crossing bells required use of track circuits through the section of track in which these test ties were located. Short circuits developed from these test ties, and occurred intermittently so that their removal was necessary during latter part of September, 1926.

Inspection of the ties following their removal indicated the following:

The steel tees (7 ft. long, 5¼ in. wide, 2½ in. high, ½ in. thick) which separated the wood blocks and served as a bearing for the rail, were in good shape, corrosion only having affected them to an extent of rust scale of about ⅛ of an inch. The bolts were tight and true but were well corroded. Wedges and lugs were still serviceable but were considerably battered from maul heads used in driving.

The wooden blocks of No. 1 tie showed marked signs of wear. One-third of the area of one of the blocks had been split out for 12 in., and one other had a well defined split running for 8 in. of its length.

Blocks of No. 2 ties were also bad, two of them having well defined soft spots of 2 in. in diameter. These soft spots begin at the outside and penetrate along the heart, going through for 6 in. or 8 in. on one and entirely through the other.

Only one block of No. 3 tie was bad, with a 1 in. diameter soft spot in the heartwood, where decay had set in which penetrated 6 in. or 8 in., if not more, along its length.

No. 4 tie had two blocks with very pronounced decay spots, which penetrated deeply along their lengths through the heartwood.

All of the blocks had splits and check marks, but rang sound under the hammer, except in one instance where rot had gone clear through. Their condition would not warrant the reinstallation of the ties in track without their renewal. Fully 60 per cent of the life of these wood blocks was gone when they were removed after a service of 4 years and 10 months.

Bangor & Aroostook Railroad

Reported by Moses Burpee, Chief Engineer.
Date—May 26, 1927.
Kind—Maine Concrete.

Sixty-nine of these ties were placed in track in 1923, and all are at present in service.

Cleveland, Cincinnati, Chicago & St. Louis Railway

Reported by HADLEY BALDWIN, Chief Engineer.
Date—June 6, 1927.
Kind—Carnegie.

Three thousand of these ties were placed in track in 1908. In 1926 all of the ties then in service (1952 ties) were removed.

All of the ties removed showed considerable corrosion in the web, quite a number to such an extent that holes had developed in the web, and in a good many of the ties the web had buckled. In some cases the flanges were warped so that the ties would not bed themselves, causing rough track.

Duluth & Iron Range Railroad

Reported by W. A. CLARK, Assistant to General Manager and Chief Engineer.
Date—June 20, 1927.
Kind—Hatch and Carnegie.

During the year nineteen Carnegie ties have been removed on account of breakage, leaving 1045 in track. Of the Hatch ties, seven are in good condition, the four remaining ties are showing considerable disintegration of the concrete.

Duluth, Missabe & Northern Railway Company

Reported by W. H. HOYT, Chief Engineer.
Date—May 26, 1927.
Kind—Carnegie and Kimball.

Of the 22,380 Carnegie ties installed in tracks in 1908 and 1909, 20,358 remain, a reduction of 364 during the year.

The thirty Kimball ties installed in 1914 are all in place and giving good service.

Elgin, Joliet & Eastern Railway

Reported by ARTHUR MONTZHEIMER, Chief Engineer.
Date—May 27, 1927.
Kind—Bates Concrete and Carnegie Steel Cross-Ties and Switch Ties.

The sixty-two Bates ties installed in 1912 are still in track and in good condition.

Carnegie cross-ties (Section M-21) have been put in at various times.

Number placed in track		15,514
Removed, 1916	50	
1917	260	
1918	182	
1919	453	
1920	306	
1921	1165	
1922	641	
1923	2620	
1924	1341	
1925	262	
1926	550	
1927	12	7,842
Number remaining in track		7,672

The Carnegie switch ties are of Section M-21 and are in yard tracks with heavy switching. The number of steel switch ties placed and removed is as follows:

Year	*Lin. Ft. of Steel Sw. Ties Used in Renewals*	*Lin. Ft. of Steel Sw. Ties Taken Up A/C Renewals*	*Lin. Ft. of Sw. Ties Used in Construction*	*Lin. Ft. of Steel Sw. Ties Taken Up A/C Track Retired*
1912	30,452	.....	5,580	.....
1913	196,333	.....	11,527	430
1914	142,939	.....	5,135	.....
1915	58,314	.....	2,023	1,615
1916	17,856	10	7,120	16,498
1917	3,789	1,907	8,623	17,340
1918	4,511	3,006	6,564	5,453
1919	6,483	526	1,582	1,582
1920	575	22,737	2,588	2,774
1921	4,712	24,855	717	4,744
1922	241	21,903	444	527
1923	846	19,451	.....	.....
1924	2,300	18,124	441	1,394
1925	180	33,700	.....	2,271
1926	1,708	37,098	255	2,550
Jan., 1927, to April, 1927, inclusive	.....	12,812	.....	192
	471,239	196,129	52,599	57,370

Linear feet of steel switch ties used in renewals and construction 523,838
Linear feet of steel switch ties taken up..... 253,499
Linear feet of steel switch ties in track at present..... 270,339

Long Island Railroad

Reported by G. P. Williams, Engineer Maintenance of Way.
Date—October 7, 1927.
Kind—Carnegie.

Of the 30 Carnegie ties placed in track at Hicksville, N. Y., in May, 1909, eighteen remain. The rail is 100 lb., the ballast is cinders and the traffic heavy passenger and freight at 20 m.p.h.

Los Angeles Railway

Reported by B. J. Eaton, Engineer Way and Structures.
Date—August 11, 1927.
Kind—McDonald Concrete.

The reconstruction of the track in which these ties were laid is in progress and they are being replaced with creosoted pine ties.

Pennsylvania Railroad—Central Region

Reported by T. J. Skillman, Chief Engineer.
Date—August 26, 1927.
Kinds—

Metal Safety Railway Ties.—These ties have all been removed on account of cracks having developed at the rail seats and difficulty in keeping the keys tight. The ties became bunched and were considered unsafe for the heavy freight traffic on this track.

Riegler Concrete Ties.—During the past year seven of the Riegler Concrete Ties were removed and repaired on account of crushing on one end under traffic. These ties have been in service 19 years, with slight repairs.

Snyder Composite Ties.—Sixty-seven of these ties in yards on the Pittsburgh Division were removed during the year on account of the filler breaking down and crushing.

Concrete Tie Company—"Casey Concrete" Ties.—We are about to place, in various freight and running tracks, additional concrete ties made by the Concrete Tie Company of Pittsburgh, Pa., as illustrated in last year's report, with slight modifications.

Pittsburg, Shawmut & Northern Railroad

Reported by J. N. Thompson, Superintendent Maintenance of Way.
Date—June 7, 1927.
Kind—Carnegie.

Seven hundred and ninety-five Carnegie ties were placed in track in 1907. During the year the last twenty-seven of these were removed because of crushing in the web under the rail.

Southern Pacific Lines

Reported by E. A. Craft, Engineer Maintenance of Way.
Date—June 17, 1927.
Kind—U. S. Indestructible Concrete.

The twenty-three ties installed near Eagle Pass in 1916 are all in good condition. Of the one hundred ties installed in February, 1926, two have been removed.

St. Louis-San Francisco Railway

Reported by F. G. Jonah, Chief Engineer.
Date—July 5, 1927.
Kind—Clark or Applegate Steel Tie.

All of the one hundred and twenty-five ties installed in 1914 are still in service. Extended comments were made in last year's report on these ties.

Terminal Railroad Association of St. Louis

Reported by H. J. Pfeifer, Chief Engineer.
Date—June 2, 1927.
Kind—Miller.

A recent inspection of the one hundred Miller ties installed in May, 1924, shows that they are in first-class condition and likely to last twenty-five to thirty years.

Tests of Substitute Ties Now in Progress—1926

Railroad	Name of Tie	Location	Date	Number Put in	Number Now in	Ballast	Rail Section Pounds	Traffic
Baltimore & Ohio	Wyckoff	Baltimore, Md	1921	4	....	Stone	100	C
Bangor & Aroostook	Maine Concrete	Hudson, Me	1923-4	69	69	Gravel	85	A
C. C. C. & St. L.	Carnegie	New Point, Ind	1908	3,000	....	Gravel	105	A
Duluth & Iron Range	Hatch	Two Harbors	1923	11	11	Gravel	80	C
	Carnegie	Various	1905	2,000	1,045	Gravel	80	C-D
Duluth, Missabe & Northern	Carnegie	Duluth & Proctor	1908-9	22,380	20,358	Crushed Rock	100	A
	Kimball	Virginia, Minn	1914	30	30	Gravel	100	C
	Bates	Whiting, Ind	1912	62	62	Gravel	85	C
Elgin, Joliet & Eastern	Carnegie	Various	Various	15,514	7,672	Gravel, Cinder and Slag.	85-100	C
	Carnegie Switch	Various	1912 and later	G522,722	G270,339	Gravel, Cinder and Slag.	80-85	E
Long Island	Carnegie	Hicksville, N. Y	1909	30	18	Cinder	100	A+
Los Angeles	McDonald	Los Angeles, Cal	1911	4,323	736	Solid Concrete	87	B
Pennsylvania Railroad—Central Region	Metal Safety	Wampum, Pa	1922	20	....	Stone	100	C
	Riegler Concrete	Emsworth, Pa	1908	15	15	Stone	130	A
	Snyder Composite	Aspinwall, Pa	1907	2,255	1,919	Cinder	100	F
	Concrete Tie Co. of Pgh. (Known as Casey Concrete Ties)	Hays, Pa. On viaduct ballast deck	1925	400	400	Stone	130	C
Pittsburg, Shawmut & Northern	Carnegie	Byrndale Br	1907	795	....	Gravel and Cinder	85	C
Southern Pacific	U. S. Indestructible	Eagle Pass, Texas	1916	23	23	Cinder	80	D
	U. S. Indestructible	Houston, Texas	1926	100	98	Gravel	90	A
St. Louis-San Francisco	Clarke or Applegate	Springfield, Mo	1914	125	....	Chats	85	C
Terminal R. R. Assn. of St. Louis	Miller	St. Louis, Mo	1924	100	100	Stone and Cinder	100	A

A—High speed, heavy service, passenger and freight.
B—High speed, exclusively passenger.
C—Heavy service, exclusively freight.
D—Main track, light service.
E—Yard track with heavy switching.
F—Yard track with light switching or storage usage
A+—Heavy passenger and freight at 20 M. P. H.

Note: G—Linear feet

Appendix E

(9) DEVELOP AND RECOMMEND A TRAFFIC UNIT FOR USE IN COMPARING CROSS-TIE LIFE

A. F. Maischaider, Chairman, Sub-Committee; H. F. Brown, C. S. Kirkpatrick, M. F. Longwill, H. M. Tremaine, J. W. Williams.

The unit desired is one which will permit of proper comparison of tie life results under varying conditions of traffic. In selecting the unit, consideration has been given to available statistics and the unit selected is proposed to be used in connection with the now available figures showing the average number of ties renewed per maintained mile for each railroad, without attempting the further refinement of making the application to individual tracks. It is the thought of your Committee that the average renewals per maintained mile, adjusted for differences in average traffic, will give the most nearly correct comparison of the results of the cross-tie practices and policies of individual carriers which can reasonably be made.

After careful consideration of the subject, your Committee recommends as this unit the "equated gross ton miles per mile of equated track per day."

This unit is derived by dividing the "total annual equated gross ton miles" by 365 and multiplying by the "equated miles of track maintained."

The "total annual equated gross ton miles" is the sum of the following items:

A = Gross freight ton miles, including locomotives and tenders.
B = Equated gross ton miles of passenger cars.
C = Equated gross ton miles of passenger locomotives.

A—"Gross ton miles including locomotives and tenders" are given as Item (8) I.C.C. Form OS. A.

B—"Equated gross ton miles of passenger cars" equal "passenger car miles" times the average weight of passenger car times the factor for greater speed of passenger trains over freight trains. Passenger car miles are given in Mileage Statistics of Annual Report. We can assume 60 tons as the average weight of passenger car and the speed factor as 2½.

We then have B equals "passenger car miles" times 150.

C = "Equated gross ton miles of passenger locomotives" equal "passenger locomotive miles" times the average weight of passenger locomotive times the speed factor.

"Passenger locomotive mileage" is given in the Mileage Statistics of Annual Report. Average weight of locomotive in working order can be arrived at approximately by taking the tractive effort (shown as Item 2.A.2 I.C.C. Comparative Statement of Operating Averages) and multiplying this by 12.

We then have C equals "passenger locomotive miles" times tractive effort divided by 2000 times 12 times 2½; or, "passenger locomotive miles" times tractive effort divided by 67.

Let D equal "equated track miles maintained," which is shown as Item 1.D in the I.C.C. Comparative Statement of Operating Averages.

The traffic unit, that is, the "equated gross ton miles per equated mile of track maintained per day" $= \frac{A + B + C}{D \times 365}$

This unit would be comparable on all railroads unless it is unbalanced too much by traffic hauled over that part of a railroad operated under trackage rights. This difference is very largely compensated for by the traffic burden that is put on the railroad by other railroads which have trackage rights.

Appendix F

(10) REPORT DATA ON AVERAGE TIES RENEWED PER MILE OF MAINTAINED TRACK

J. H. Roach, Chairman, Sub-Committee.

A careful investigation of the data available up to 1926 indicates that because of complications between "operated" and "maintained" mileage, and for other reasons not necessary to repeat here, results derived for representative roads would be from 1 to 26 per cent in error. As the statistics in the revised form recommended by this Committee will be available from 1927 on, it has been thought best to defer the first report on this subject until next year.

REPORT OF COMMITTEE XVIII—ELECTRICITY

AND OF THE

ELECTRICAL SECTION—AMERICAN RAILWAY ASSOCIATION

EDWIN B. KATTE, *Chairman;*
F. AURYANSEN,
B. F. BARDO,
H. M. BASSETT,
R. BEEUWKES,
D. J. BRUMLEY,
J. C. DAVIDSON,
J. H. DAVIS,
J. V. B. DUER,
F. D. HALL,
W. L. MORSE,
R. J. NEEDHAM,
SIDNEY WITHINGTON, *Vice-Chairman;*
A. E. OWEN,
J. A. PEABODY,
M. SCHREIBER,
W. M. VANDERSLUIS,
H. M. WARREN,
L. S. WELLS,
C. G. WINSLOW,
R. P. WINTON,
G. I. WRIGHT,
A. H. WOOLLEN,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual (Appendix A).

(2) Study of electrical interferences caused by propulsion circuits including recommendations for eliminating interferences with signal, telephone and telegraph lines caused by propulsion circuits and adjacent transmission lines (Appendix B).

(3) Study and report on the utilization of water power for electric operation, with particular reference to the international development of power on the St. Lawrence River, the tidal power project on the Passamaquoddy Bay, water power development on the Saguenay River and water power development on Gatineau River, near Ottawa, Ontario (Appendix C).

(4) Collaboration with American Committee on Electrolysis (Appendix D).

(5) Collaboration with the U.S. Bureau of Standards in the revision of the National Electrical Safety Code (Appendix E).

(6) Study of design and construction for catenary-supported working conductors (Appendix F).

(7) Study of economics of railway location as affected by electrical operation, collaborating with Committee XVI—Economics of Railway Location (Appendix G).

(8) Study and report on Specifications for Rubber Insulating Tape, collaborating with Telegraph and Telephone Section, Signal Section, and Mechanical Division (Appendix H).

(9) Revision of Insulator Specifications previously adopted (Appendix I).

(10) Revision of the Tables showing Third-Rail Clearances and Overhead Working Conductor Clearances (Appendix J).

(11) Study and report on Rules for the Protection of Oil Sidings from Danger Due to Stray Currents (Appendix K).

(12) Study and report on Specifications for Track and Third-Rail Bonds for Electric Railway Circuits, with particular reference to: (a) Developing a standard specification for measurement of bond resistance; (b) securing data on current carrying capacity of bonds; (c) details on bond design; (d) the effect of heat of welded bonds on track rails, co-operating with the Rail Committee; and (e) means of attaching bonds to manganese track rails (Appendix L).

(13) Revision of Schedule of Incandescent Lamps and report on Flood Lights for Classification Yards and for other railroad purposes (Appendix M).

(14) Study and report on the Design of Indoor and Outdoor Substations (Appendix N).

(15) Study and report on Design and Specifications of High Tension Cables (Appendix O).

Action Recommended

(1) That no changes be made in the subject-matter of the Manual this year other than the removal of the present lamp schedule.

(2) That the report on Inductive Co-ordination in Appendix B be accepted as an indication of progress and the subject continued.

(3) That the report on Water Power in Appendix C be accepted as information and the general subject continued.

(4) That the report on Electrolysis in Appendix D be accepted as progress and the subject continued, with representation on the American Committee on Electrolysis without commitment as to subscription or dues.

(5) That the report on co-operation with the U.S. Bureau of Standards in Revision of National Electrical Safety Code under the procedure of the American Engineering Standards Committee, as contained in Appendix E, be accepted as information and the co-operation continued with the U.S. Bureau of Standards.

(6) That the report on Overhead Transmission Lines and Catenary Construction in Appendix F be accepted as a progress report and the subject continued. It seems at present too early to include the specifications on transmission lines in the Manual.

(7) That the report on collaboration with Committee XVI—Economics of Railway Location, contained in Appendix G, be accepted as a progress report and the subject continued.

(8) That the report on Standardization of Friction and Rubber Tapes Specifications contained in Appendix H be accepted and the subject continued.

(9) That the report on Insulator Specifications as set forth in Appendix I be accepted as information and the subject continued.

(10) That the report on Clearances for Third-Rail and Overhead Working Conductors, Appendix J, be accepted as information and the subject continued.

(11) That the report on Protection of Oil Sidings from Danger Due to Stray Currents, Appendix K, be accepted as a progress report and the subject continued.

(12) That the report on Specifications for Track and Third-Rail Bonds, Appendix L, be accepted as a progress report and the subject continued.

(13) That the revised schedule of Incandescent Lamps in Appendix M be accepted as information and the subject continued. That the present schedule be eliminated from the Manual.

(14) That the report on Design of Indoor and Outdoor Substations in Appendix N be accepted as a progress report and the subject continued.

(15) That the report on High Voltage Cables, Appendix O, be accepted as a progress report and the subject further investigated.

Recommendations for Future Work

(1) Revision of the Manual as may be found necessary.

(2) Continue the subject of Inductive Co-ordination, as well as representation on the American Committee on Inductive Co-ordination.

(3) Report further on the tidal water power development on Passamaquoddy Bay and on the St. Lawrence River, when actual construction is in progress; also report on the Alabama power development on the Tennessee River and present information as to the extent that water power is used for railroad operation at the present time.

(4) Continue representation on the American Committee on Electrolysis without commitment as to subscription or dues.

(5) Continue collaboration with the U.S. Bureau of Standards in the revision of the National Electrical Safety Code and other Codes of similar character. Continue the study of Electric Light, Power Supply, and Trolley Lines Crossing Railroads, with a view to keeping the Association informed with regard to changes which may be desirable in the specifications. Continue State representatives and their alternates.

(6) Revise and keep up to date the Transmission Line and Catenary Specifications.

(7) Continue the study of Economics of Railway Location as affected by electric operation, collaborating with Committee XVI—Economics of Railway Location.

(8) Continue the study of insulating tapes, with especial reference to cambric and paper tapes.

(9) Continue the study of insulators, with a view of keeping up to date the specifications previously adopted.

(10) Review the subject of clearances of overhead conductors, with a view of harmonizing discrepancies which now exist in various specifications, collaborating with the Special Committee on Clearances and other Committees as may be necessary.

(11) Continue the study of protection of oil sidings from danger due to stray currents, with a view to keeping up to date rules previously adopted.

(12) Continue the study of track and third rail bonds, with especial reference to:

(a) Study of details of bond design with a view to developing specifications covering the different classes of bonds.
(b) Collection of information as to methods and extent of practice in re-applying bonds.
(c) Collection of data on composition used, if any, on rail joints to replace bonds.
(d) Study of contact areas and resistances for different types of bonds.
(e) Compiling information concerning rail joint clearance and its effect on rail bond design.

(13) Revise and keep up to date the incandescent lamp schedule. Continue the study of flood lighting for classification yards and for other railroad purposes.

(14) Continue the study of design of indoor and outdoor substations.

(15) Investigate cables for carrying high voltages.

Respectfully submitted,

The Committee on Electricity,

By Sidney Withington, *Vice-Chairman.*

Appendix A

(1) REVISION OF MANUAL

W. M. Vandersluis, Chairman, Sub-Committee; A. E. Owen, Vice-Chairman, Sub-Committee; J. H. Davis, E. B. Katte, W. L. Morse.

Conclusions

(1) Remove from the Manual the 1926 Tungsten Lamp Schedule as approved at the Annual Meeting in March, 1927, Appendix M, pages 128-131, Vol. 28, No. 291, November, 1926.

Appendix B

(2) INDUCTIVE CO-ORDINATION

J. V. B. Duer, Chairman, Sub-Committee; Sidney Withington, Vice-Chairman, Sub-Committee; R. Beeuwkes, J. C. Davidson, E. B. Katte, W. M. Vandersluis.

The Sub-Committee reports that it has been following the work of the American Committee on Inductive Co-ordination through the representatives of the American Railway Association on this Committee: E. B. Katte, J. V. B. Duer, L. Behner, W. A. Jackson, W. F. Follett, and G. H. Dryden (Alternate).

There have been no meetings of the American Committee on Inductive Co-ordination since the last meeting of the Electrical Section, and the Sub-Committee therefore has no report to make at this time.

It will continue to follow the work of the American Committee on Inductive Co-ordination and report its activities in this connection from time to time.

Conclusions

That this subject be continued and the activities of the Sub-Committee for the present be confined to collaboration with the American Committee on Inductive Co-ordination.

Appendix C

(3) WATER POWER

R. J. Needham, Chairman, Sub-Committee; W. L. Morse, Vice-Chairman, Sub-Committee; H. M. Bassett, R. Beeuwkes, J. C. Davidson, H. Flood, Jr., F. D. Hall.

The Sub-Committee was instructed to investigate and report on the progress of the following water power developments:

1. The International development of Power on the St. Lawrence River.
2. The tidal water power project on the Passamaquoddy Bay, off the Bay of Fundy.
3. Water power development on the Saguenay River, near Lake St. John, in the Province of Quebec.
4. Water power development on Gatineau River, near Ottawa, Ontario.

Members of this Sub-Committee were also delegated during the past summer to represent the American Railway Engineering Association and the Electrical Section of the American Railway Association at the Southern Appalachian Power Conference which was held at Chattanooga, Tennessee, on October 13th, 14th, and 15th. W. L. Morse, Vice-Chairman, attended the Conference.

A strong program relating to the possible power developments in the Southern states and means of presenting proper information to the general public relative thereto was presented and followed by discussion led by speakers of note. It has been reliably estimated that by 1940 the Southern states will need 6,000,000 H.P. The United States Geological Survey places the possible water power development at 5,000,000 H.P. To properly co-ordinate this power was the purpose of the Conference and since the development of these states depends largely on this co-ordination, the railroads have reason to be interested and to be informed on the subject. The first development will probably come from the building of eleven dams on the upper Tennessee River between Chattanooga and Knoxville, application to do which has been made to the Federal Power Commission by the East Tennessee Development Company. The granting of the permit is now awaiting disposition of the Muscle Shoals question; when granted it will open a topic for this Sub-Committee to consider and report upon to the Association.

ST. LAWRENCE RIVER POWER DEVELOPMENT

Considerable engineering data have been collected, but no actual construction work has been done. The matter is still under consideration between the Federal Governments of the United States and Dominion of Canada. Inasmuch as this is an international waterway, the consent of both countries is required.

TIDAL WATER POWER PROJECT AT PASSAMAQUODDY BAY

A considerable amount of preliminary engineering data have been assembled and investigation undertaken, in connection with this project, but no actual construction work has been started. This is also an international development which will require the sanction of the United States and Canadian Governments.

DEVELOPMENTS ON THE SAGUENAY RIVER

The Saguenay River flows from Lake St. John about ninety miles south into the St. Lawrence River, located in the Province of Quebec, Canada. There are two desirable water power locations, one at Isle Maligne, close to Lake St. John, and the other at Chute a Caron, twenty miles further down the river.

The Isle Maligne development contemplates an ultimate capacity of 540,000 H.P., of which 450,000 H.P. is at present in service, with a head of 110 feet. A fuller description of this installation has been submitted in a previous report.

At Chute a Caron, near Arvida, a town recently brought into existence as a result of the larger undertakings of the Aluminum Company of America, the site is now being cleared for the second development.

The power plant will be located near the mouth of the Shipshaw River, a small branch of the Saguenay River. The dam at Chute a Caron will be 200 feet high, 3400 feet long, and will require 250,000 cubic yards of

concrete. The water will be conveyed through a canal two and one-half miles long, across a small neck of land, to the power plant at the mouth of the Shipshaw River. This canal will range from 70 to 300 feet in width, with a maximum depth of 150 feet. The total ultimate capacity of this development will be 720,000 K.V.A. Twelve generators are to be installed of 60,000 K.V.A. capacity each. The head at the power plant will be 210 feet.

The Saguenay River receives its water from Lake St. John, which is 26 miles long by 18 miles broad, with an elevation of 341 feet above sea level. This lake has a drainage area of 30,000 square miles, and a storage capacity to 19 feet draw down of 200,000,000,000 cubic feet. The average controlled flow of the river is 40,000 sec.-feet.

Sketch showing the portion of the river on which the two developments are located accompanies the report.

GATINEAU WATER POWER DEVELOPMENT

The Gatineau River flows from Lake Piskatosson to the Ottawa River, a distance of 127 miles, entering the Ottawa River near the City of Ottawa, and is located in the Province of Quebec, Canada.

The fall from the source to the mouth of the river is 598 feet. There are four locations suitable for power development, namely, Farmers, Chelsea, Pougan and Miniwaki, with a total capacity of 662,000 H.P.

The drainage area of this river above the Chelsea plant is 9600 square miles. Near the source of the river a large reservoir has been erected by what is known as the Mercier Storage Dam, in which is impounded 96 billion cubic feet of water. This reservoir will be the third largest artificial storage reservoir in the world, the others being the lake above the Gatun dam, in the Panama Canal Zone, and the Gouin Dam on the St. Maurice River, in the Province of Quebec. The ultimate regulated flow of the river has been estimated to be between ten and eleven thousand cubic sec.-feet.

A diagrammatic map showing location of power houses and transmission lines accompanies the report.

FARMERS DEVELOPMENT

The Farmers plant, with a capacity of 120,000 H.P., is located seven miles from the Ottawa River, and is designed for five units of 24,000 H.P. capacity each, three of which have already been installed, and the fourth one is now in progress of installation. The length of dam, including spillway, power-house section, and wing dams, is 4800 feet; maximum height 75 feet. The operating head is 65 feet.

CHELSEA DEVELOPMENT

The Chelsea plant, with a capacity of 170,000 H.P., is located 7000 feet above the Farmers plant, and the water is backed up from the Farmers plant to the tail race of the Chelsea plant. The latter has space provided for

five units of 34,000 H.P. each. Three of these units are in operation, and the fourth is being installed. The plant operates under a head of 96 feet. The dam is 1600 feet long and 100 feet high, and will back the river up 26 miles to the tail race of the Paugan Falls, impounding about 440,000,000 cubic feet of water.

PAUGAN DEVELOPMENT

The Paugan plant, which is now under construction, has a capacity of 272,000 H.P., being designed for eight units of 34,000 H.P. each, of which the initial installation will be six units. The dam will back the water up a distance of 30 miles, submerging nine falls and rapids, and creating a head of 136 feet.

MINIWAKI DEVELOPMENT

No construction work has yet been undertaken at the Miniwaki power project. The proposed plant for this development will have a capacity of 100,000 H.P.

Generators in these plants operate on a voltage of 6600, stepped up at the Farmers and Chelsea plants to 110,000 for transmission to the Gatineau Paper Mills on the Ottawa River, and to 220,000 volts at the Paugan plant for transmission to Toronto, Ontario, to connect in with the Hydro-Electric Power Commission's system. The Paugan plant will operate on 25 cycles. The Farmers and Chelsea plants are operated on 60 cycles, but have some 25-cycle generators, to be used in conjunction with the Paugan plant. A 225-mile transmission line will carry power from the Paugan plant to Toronto.

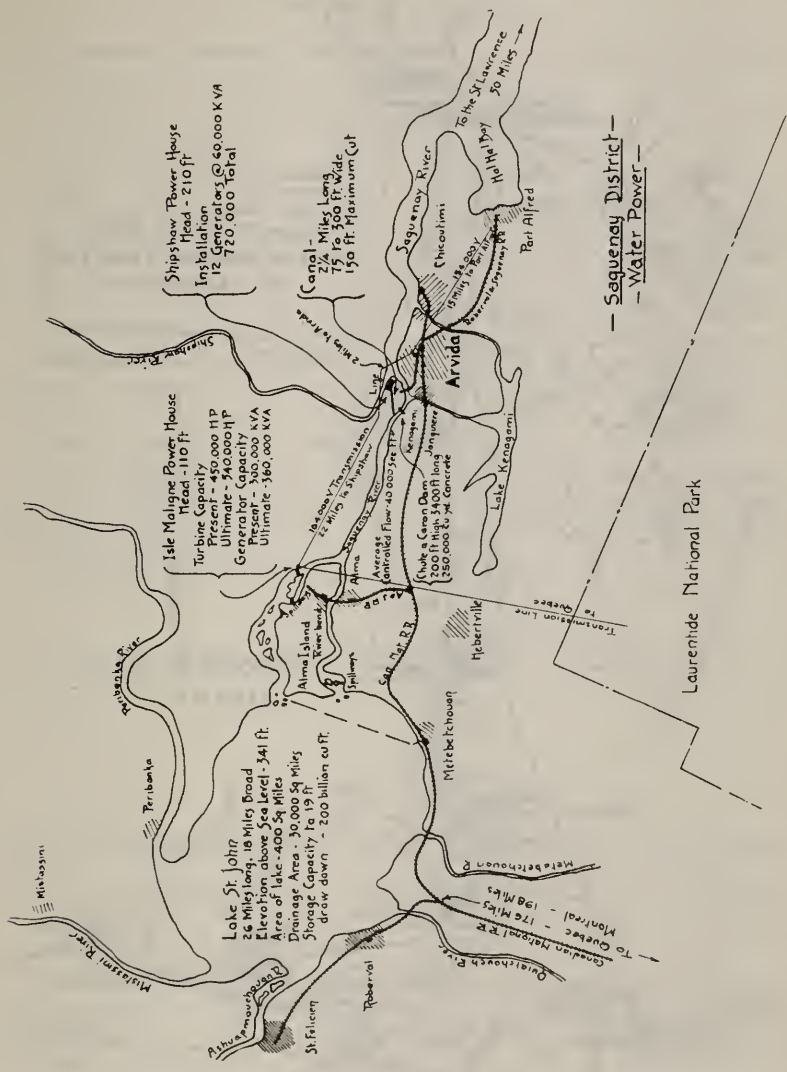
POWER PROJECTS ON THE TENNESSEE RIVER

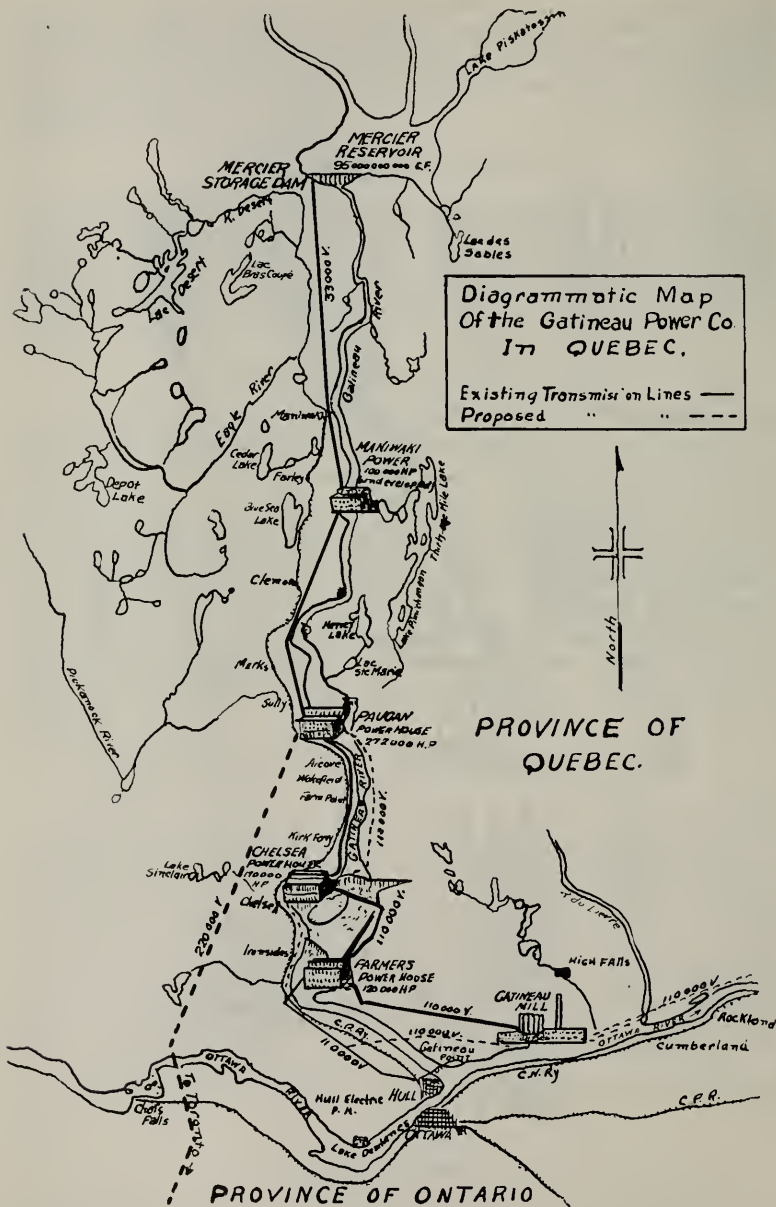
It has been reported that Major Harold C. Fiske of the U.S. Army, Chief of the Tennessee Valley Survey, has recently announced a plan that contemplates the building of one hundred dams with a possible output of 4,000,000 horsepower on a 400-mile stretch of the Tennessee River between Paducah, Kentucky, and Knoxville, Tennessee. The plan proposes a system of artificial lakes and the deepening of the Tennessee River so that ships may travel from Knoxville through the Tennessee, Ohio and Mississippi Rivers to the Gulf of Mexico, and a ship canal from the Tennessee River to the Tombigbee River to give this vast interior country still another port at Mobile, Alabama.

This project will be made the subject of a special report for the coming year.

Conclusions

This report is submitted as information, with the recommendation that the subject be continued.


Shipshaw Power House
Head - 210 ft
Installation
12 Generators @ 60,000 KVA
720,000 Total
Canal -
2¼ Miles Long
75 to 300 ft. Wide
150 ft. Maximum Cut
Isle Maligne Power House
Head - 110 ft
Turbine Capacity
Present - 450,000 HP
Ultimate - 540,000 HP
Generator Capacity
Present - 300,000 KVA
Ultimate - 360,000 KVA
Lake St. John
26 Miles long, 18 Miles Broad
Elevation above Sea Level - 341 ft.
Area of lake - 400 Sq Miles
Drainage Area - 30,000 Sq Miles
Storage Capacity to 19 ft
draw down - 200 billion cu ft.
Saguenay River
Chicoutimi
Hat Hat Bay
Port Alfred
To the St Lawrence
50 Miles
Arvida
Lake Kenogami
Chute a Caron Dam
200 ft High 3400 ft long
250,000 cu yd Concrete
Average
Controlled Flow - 40,000 Sec ft
Alma
Alma Island
Spillways
Hebertville
Metabetchouan
Metabetchouan R
Peribonka
Peribonka River
Mistassini
Mistassini River
Ashuapmouchouan R
St. Felicien
Roberval
Quiatchouch River
Canadian National R.R.
To Quebec - 176 Miles
Montreal - 198 Miles
Transmission Line to Quebec
Laurentide National Park
— Saguenay District —
— Water Power —


Diagrammatic Map
Of the Gatineau Power Co.
In QUEBEC.
Existing Transmission Lines
Proposed " "
North
MERCIER RESERVOIR
MERCIER STORAGE DAM
Lac des Sables
Lac Desert
Lac Bras Coupé
33000 V.
Gatineau River
Eagle River
Maniwaki
Cedar Lake
Farley
Depot Lake
Blue Sea Lake
MANIWAKI POWER
Clemons
Hervey Lake
Lac Ste Marie
Marks
Sully
PAUGAN POWER HOUSE
272000 H.P
Pickamack River
Aircore
Wakefield
Farm Point
Kirk Ferry
CHELSEA POWER HOUSE
Lake Sinclair
Chelsea
Ironsides
220000 V.
110000 V.
FARMERS POWER HOUSE
120000 HP
GATINEAU MILL
High Falls
Rockland
Cumberland
Gatineau Point
C.N. Ry
C.P.R.
Hull Electric P. H.
HULL
OTTAWA
Lake Deschenes
Chats Falls
PROVINCE OF QUEBEC.
PROVINCE OF ONTARIO

Appendix D

(4) ELECTROLYSIS

M. Schreiber, Chairman, Sub-Committee; W. M. Vandersluis, Vice-Chairman, Sub-Committee; E. B. Katte.

There has been one meeting of the American Committee on Electrolysis since the report of March, 1926, was submitted.

The Sub-Committee on Research reported having assisted in revising a chapter on stray current electrolysis prepared by a member for the book on "Corrosive Engineering," compiled by Dr. F. N. Speller. Considerable attention to the various aspects of the "Grounding Rules" was also reported. The Sub-Committee advised that it had criticized a paper on "Electrolysis Mitigation," by E. R. Shepard, as submitted by the Bureau of Standards.

Due to the fact that two parent organizations of the American Committee on Electrolysis had resigned, the question of continuing the committee was thoroughly discussed. The need of having such a committee to handle electrolysis and closely related questions and investigations was expressed by representatives present.

Resolutions were finally passed covering the continuing of the committee, extending invitations to the two organizations which had resigned to return, and the enlarging of the committee to include organizations handling allied subjects.

Information as to further activities of the committee is expected shortly.

Conclusions

That representation on the American Committee on Electrolysis be continued.

Appendix E

(5) CO-OPERATION WITH U.S. BUREAU OF STANDARDS

W. L. Morse, Chairman, Sub-Committee; F. Auryansen, Vice-Chairman, Sub-Committee; B. F. Bardo, J. H. Davis, J. V. B. Duer, J. T. Seaver, Z. H. Sikes, L. S. Wells.

The Sub-Committee has through correspondence and by conference conferred with the U.S. Bureau of Standards in the revision of the National Electrical Safety Code, under the procedure of the American Engineering Standards Committee.

Progress in relation to various parts of the Code has been made as follows:

On November 15th, 1927, the American Engineering Standards Committee approved the entire revised Code as American Standard, designating

it as Number C2-1927. Various parts of the Code as heretofore printed by the Bureau of Standards and now available as separate publications (Handbooks 6 to 9, inclusive) are now being printed together under one cover as a new edition of Handbook No. 3 of the Bureau of Standards.

Part 1—Rules for the Installation and Maintenance of Electrical Supply Stations, and Section 9—Grounding Rules; Part 4—Rules to be Observed in the Operation of Electrical Equipment and Lines, and Part 5—Safety Rules for Radio Installation, have each been previously recommended for acceptance by the American Railway Association when the entire Code has finally been revised.

Part 2—Rules for the Installation and Maintenance of Overhead and Underground Electrical Supply Lines: The previous report in regard to this part of the Code was that it had not been found satisfactory, particularly in respect to clearances and strength of structures where long spans and high voltages were involved and because of this the American Railway Association representatives submitted to the Chairman of the Sectional Committee under date of June 30th, 1926, a minority report dated June 18th, 1926. It was also previously reported that following a conference on October 27th, 1926, representatives of the National Electric Light Association and representatives of the American Railway Association would confer with a view toward reconciling differences with the part of the Code affecting overhead supply lines crossing railroads.

The representatives of the two associations above referred to effected an agreement, authority to sign which was obtained by the representatives of the American Railway Association and which agreement has been filed with the Chairman of the Sectional Committee as quoted below:

Altoona, Pa., September 17, 1927.

Mr. M. G. Lloyd,
Chairman, Sectional Committee for Parts II and IV,
National Safety Code, Bureau of Standards,
Washington, D. C.

Dear Sir:

The American Railway Association, through its representatives, will accept Part 2 of the National Electrical Safety Code revised as of April, 1926, with the following specific statement of its position in regard to that portion of this part of the Code covering power wire crossings over railroads:

1. It disagrees with the values of separation of conductors on the same support, particularly those which carry potentials in excess of 7500 volts and those in spans in excess of 400 feet.
2. It disagrees with the values of vertical clearance at the crossing of power lines over railroads.
3. It disagrees with the method of determining the loading on crossing supports.
4. It disagrees with the unit stresses specified for steel.
5. It disagrees with the difference between the longitudinal load specified for continuous and for isolated construction.
6. It disagrees with the theory which permits the same flashover value for insulators at a railroad crossing as in the rest of the line.

The American Railway Association, through its representatives, agrees to co-operate with the National Electric Light Association in the preparation of a mutually satisfactory general agreement as to Principles and Practices, with accompanying specifications, covering power wire crossings over railroads to be made the standard of both Associations covering this subject.

The Minority Report, covering Part 2 of the Code, submitted by the American Railway Association under date of June 18, 1926, is hereby withdrawn.

E. C. Keenan W. L. Morse
G. H. Dryden J. V. B. Duer
A.R.A. Representatives.

The National Electric Light Association, appreciating the position of the American Railway Association with respect to Part 2 of the Code, will appoint representatives to co-operate with the American Railway Association representatives in preparing a mutually satisfactory general agreement as to Principles and Practices, with accompanying specifications, covering power wire crossings over railroads, which when completed will be made the standard for both Associations covering this subject.

J. C. Martin H. S. Bennion
W. C. Wagner Thomas Sprouls
N.E.L.A. Representatives.

For the preparation of the general agreement as to Principles and Practices, with accompanying specifications, the following representatives of the American Railway Association have been appointed:

J. V. B. Duer, representing the Electrical Section,
W. L. Morse, representing the Construction and Maintenance Section,
E. C. Keenan, representing the Telegraph and Telephone Section,
G. H. Dryden, representing the Signal Section.

Part 3—Rules for the Installation and Maintenance of Electrical Utilization Equipment: It has been found that the Minority Report previously reported was filed with the Sectional Committee subsequent to the printing of this part of the Code and in such form that the Chairman of the Sectional Committee took it to be a letter of objections rather than a Minority Report from the representatives of the American Railway Association.

Considering the above facts it would appear that changes to rules 381 (b) and 382 (c) (2), should be taken under consideration when this part of the Code is next revised.

Conclusions

That the work be continued in co-operation with the U.S. Bureau of Standards for the revision of the National Electrical Safety Code under the procedure of the American Engineering Standards Committee for any part of the Code that may be reopened or in the preparation of specifications for Supply Lines crossing Railroads and with representatives of the National Electric Light Association in the preparation of a general agreement as to Principles and Practices, with accompanying specifications, covering power wire crossings over railroads to be made the standard of both Associations.

Appendix F

(6) OVERHEAD TRANSMISSION LINE AND CATENARY CONSTRUCTION

L. S. Wells, Chairman, Sub-Committee; G. I. Wright, Vice-Chairman, Sub-Committee; F. Auryansen, B. F. Bardo, H. M. Bassett, J. C. Davidson, J. V. B. Duer, F. D. Hall, P. S. Mock, R. J. Needham, H. Pattison, J. A. Peabody, H. W. Pinkerton, J. E. Sharpley, R. P. Winton, S. Withington.

The following is an outline of the work under consideration by this Sub-Committee:

1. Revise and keep up-to-date the transmission line specifications previously adopted.
2. Continue the study of design and construction for catenary supported working conductors.

The Sub-Committee submits for consideration its report, as follows:

1. The Sub-Committee has considered the transmission line specifications previously adopted and has no changes or additions to recommend at this time.
2. The work of Sub-Sub-Committees 1, 2 and 3 has been advanced and co-ordinated. Sub-Sub-Committee 2, with the co-operation of Sub-Sub-Committee 3, has developed a preliminary draft of specifications covering design and construction for catenary supported working conductors. This draft has been reviewed by the full Committee, following which certain changes and additions have been incorporated. The revised specifications in tentative form are submitted herewith. Their requirements with respect to loading, unit stresses, etc., conform in general with those of the transmission line specifications. The specifications are subject to further revision, particularly such parts as relate to loading, unit stresses and clearances. It is the feeling of your Committee that further consideration of these features should be deferred until such time as the work of Sub-Committee No. 5, jointly with the National Electric Light Association, in the preparation of wire crossing specifications satisfactory to the railroads, has been concluded.

Conclusions

It is recommended that this subject be continued.

SPECIFICATION FOR CATENARY CONSTRUCTION FOR RAILROAD USE

Preliminary Draft Revised 9/13/27.

GENERAL

1. Scope

These specifications describe the recommended practices for the design and construction of overhead contact systems of the catenary type with rail return. In all cases of joint construction with transmission lines, except where specific modification is contained herein, they shall conform to the

requirements of the A.R.A. "Specifications for the Construction of Overhead Electric Supply Lines for Railroad Use on Railroad Property," in case these latter requirements are more severe. The systems covered are designated as follows:

(A) Single phase Alternating Current Catenary System.
(B) Direct Current Catenary System over 700 Volts Nominal.

2. Definitions

Catenary Suspension.—Term catenary as used in these specifications means all forms of suspension of overhead contact systems in which the contact member is supported at more or less regular intervals by one or more messenger cables to produce a contact surface nearly parallel to top of track rail. The catenary system is made up of supporting cables referred to as messengers, the working conductor which is referred to as the contact wire (or trolley) and the connecting members called the hangers, together with auxiliary conductors if required.

Classification.—Catenary construction may be classified under three general heads, first, as to alignment, second, as to messenger system, and third, as to the contact system.

Under alignment there are two general types, tangent-chord construction and inclined construction.

As to messenger classification, there are three general types: (1) single catenary construction, (2) double catenary construction, and (3) compound catenary construction.

As to contact classification there are three general types, the single, the duplex or tandem and the double or twin contact.

Tangent-Chord Catenary is that construction in which, on curves, the catenary is the same as on tangent, suitably deflected at proper intervals.

Inclined Catenary is that type in which, on curves, the messenger system not only supports the vertical load but also carries the horizontal load reaction of the entire system, the hangers assuming the direction of the resultant force.

Single Catenary is that construction consisting of one or more contact wires supported by a single messenger.

Double Catenary is that construction consisting of one or more contact wires, with auxiliary conductors if used, supported by triangle or V hangers from two messengers having the same vertical sag and which are supported from the same elevation in the same span.

Compound Catenary is that construction where one or more contact wires are supported by a secondary messenger, which in turn is supported by a primary messenger.

Messenger System

The Primary Messenger is the cable which carries the entire load of the catenary system and which is attached to the supporting structures.

The Secondary Messenger is the cable which is attached to the contact wires by hangers and is supported by the primary messenger.

Hangers

The Hanger is the device of a length varying with the messenger sag used for attaching the contact wires to the messenger system, at more or less regular intervals.

The Messenger Hanger is the device which may be of varying length used for attaching the secondary messenger to the primary messenger.

A Lacing Messenger is a flexible continuous conductor which is attached alternately to the messenger system and the contact wires at more or less regular intervals as a substitute for hangers.

Contact System

Single Contact type consists of but one conductor which is the contact wire, supported by the messenger system.

The Duplex or Tandem type of contact consists of a contact wire supported by one or more auxiliary conductors directly above by members known as auxiliary clips which are always the same length.

Double or Twin Contact type consists of two contact wires held in approximately the same horizontal plane, usually by alternate hangers or clips.

The Contact Wire is the wire member with which sliding or rolling contact is made by the current collecting device.

Supporting Structures

The supporting structure is the pole, tower, bridge, etc., used for supporting the catenary system and includes foundations, anchors, guys, braces and similar reinforcing attachments. Supporting structures are classified as:

Bracket Construction consisting of an arm attached to a supporting pole or tower at one side of the track.

Bridge Construction consisting of a transverse beam, truss or similar rigid member attached to poles or towers at both sides of the track or tracks.

Cross Span Construction consisting of a transverse cable or similar flexible member attached to poles or towers at both sides of the track or tracks.

Included with the supporting structures are steady braces and steady spans. A Steady Brace is a rigid member normally unstressed connecting the contact wire to the supporting structure. A Steady Span is the flexible member used with bridge or cross span construction between supports to steady either the messenger wire or the contact wire.

With the supporting system are included those members, either rigid or flexible, which sustain the horizontal load due to change in alignment. They are classified as Pull-Offs, consisting of tension members between

the messenger or contact wires and the supporting structure; PUSH-OFFS, consisting of compression members between the messenger or contact wire and the supporting structure, and BRIDLES, extending between supporting structures and attached to the catenary system at points between supports. WIND BRACING may consist of steady braces, steady spans or bridles, as defined above.

A DEFLECTOR is a device or construction used at track switches or turnouts to hold the contact wires over each track in the same horizontal plane to prevent the current collecting device on the car or locomotive from fouling when passing from one contact wire to another.

3. Preliminary Considerations

(a) Determine the extent of initial and probable ultimate electrification of main tracks, yards and sidings, having in mind possible additions of trackage and other physical changes, in order that the structures can be so designed and located as to require the least alteration to meet changed conditions.

(b) Determine the source or sources of power supply, present and future, so that catenary supporting structures may be proportioned to accommodate the loading of initial and future transmission lines and feeder circuits.

(c) Determine the initial, and, as far as possible, the ultimate train schedules, passenger and freight, in each direction, inclusive of headway, length of trains, weight, speed, etc., so that adequate electrical capacity may be provided in the catenary construction.

(d) In laying out the catenary construction, bear in mind the effect of ballast changes, the correction of surface or alignment, construction of future buildings or other structures such as bridges, etc., along or over tracks.

(e) Conduct a complete survey of the physical roadway property involved in the electrification so that preferred locations for supporting and guying structures may be determined with due regard to physical obstructions, nature of soil, possible future improvements, signals, signal control lines, communication lines and other local considerations.

4. Protective Coating

(a) Steel poles, towers, or supporting structures, bolts, nuts, washers, guys, guy clamps, turnbuckles, anchors, anchor rods and similar items of material subject to rapid corrosion under prevailing conditions shall be of corrosion resisting material, or shall be protected by galvanizing, painting, or both, or other treatment which will effectively retard corrosion. Material subject to corrosion shall be thoroughly cleaned at the shop before treatment by corrosion resisting applications.

(b) Galvanizing shall be by means of hot dip process, in accordance with A.R.A. Specification for galvanizing. Material to be galvanized shall be cut, drilled or punched or otherwise worked before galvanizing.

(c) When painting is required an approved paint shall be used and painting shall consist of one shop coat on contact surfaces before assembling, one complete shop coat and one or more complete field coats after erection. Before painting in the field, the surface shall be thoroughly cleaned, and worn or defaced spots, field rivets and bolts shall be touched up. No painting shall be done on frosted or wet surfaces.

5. Guards and Warning Signs

(a) Supporting structures and guys exposed to traffic or damage which will materially affect their strength shall be protected by suitable guards, preferably painted white.

(b) Warning signs shall be provided where local conditions require their use.

CLEARANCES

6. Clearances from Tracks

Vertical and horizontal clearances from tracks shall be in accordance with A.R.E.A. clearance diagrams.

7. Clearance from Live Catenary Construction

The clearance between any live portion of the catenary in its normal position and the surfaces of overhead grounded structures shall be as great as possible, preferably not less than 5.0 inches plus the maximum possible displacement of the live catenary.

8. Clearances at Highways, Canals, Creeks and Navigable Streams

The clearances of lines over highways, canals, creeks and navigable streams will depend on local conditions and shall be in compliance with Federal, State and local requirements.

LOADING

9. General

(a) The district loading map (see Appendix reference) shows the recognized division of the continental territory of the United States into three districts known as Heavy, Medium and Light Loading Districts for the purpose of pole line construction. This division shall be held to apply to catenary construction. Other loadings may be used where they better represent conditions in a particular locality. In arriving at an assumed loading, the experience of the railroad concerned, Weather Bureau wind velocity records, local records of ice coating, direction of the line, direction of prevailing winds, shelter and such other modifying features may be considered.

(b) In the calculation of stresses no reduction in assumed load shall be made on account of deformation, deflection or displacement of any part of the supporting structure, including the suspension insulators.

10. Heavy Catenary Loading (H)

Heavy loading on the catenary shall be the weight of the wires, cables and accessories plus the weight of a coating of ice ½ inch in radial thickness combined with a transverse horizontal wind pressure of 8 lb. per sq. ft. on the projected area of the ice covered wires, cables and accessories at 0° Fahr.

11. Medium Catenary Loading (M)

Medium loading on the catenary shall be the weight of the wires, cables and accessories plus the weight of a coating of ice ¼ inch in radial thickness combined with a transverse horizontal wind pressure of 10 lb. per sq. ft. on the projected area of the ice-covered wires, cables and accessories at 15° Fahr.

NOTE.—The weight of ice shall be assumed as 57 lb. per cu. ft. (0.033 lb. per cu. in.)

12. Light Catenary Loading (L)

Light loading on the catenary shall be the weight of the wires, cables and accessories combined with a transverse horizontal wind pressure of 15 lb. per sq. ft. on the projected area of the wires, cables and accessories at 32° Fahr.

13. Loading on Supports

On supporting structures having cylindrical surfaces, the wind pressure per sq. ft. for heavy, medium and light loading shall be the same as that specified in Sections 10, 11 and 12, respectively. On flat surfaces, these unit wind pressures shall be increased by 60 per cent. On latticed structures the wind pressure shall be taken on the actual exposed area of one face, increased by 50 per cent. The total thus obtained for latticed structures need not be considered in excess of that for a solid structure of the same outside dimensions. In calculating the wind pressure, ice covering on supporting structures may be neglected.

14. Vertical Loading

The vertical loads upon poles, towers, foundations, crossarms, bracket arms, pins, insulators and attachments shall be their own weight plus the superimposed weight of the catenary construction which they support, ice coated where specified, together with the effect of any difference in elevation of supports.

15. Transverse Loading

The transverse loading on poles, towers, foundations, crossarms, bracket arms, pins, insulators, and attachments shall be that due to the horizontal wind pressure specified for the district (in which the construction is located) in Sections 10, 11 or 12 on the catenary construction, ice covered where

specified, the wind pressure (for the said district) on the structures themselves as specified in Section 13, together with any transverse load due to a turn, curve or angle in the line. On structures carrying light curve pulls the transverse pressure due to wind in reverse direction should be considered.

16. Longitudinal Loading

(a) The longitudinal loading on supporting structures (except as provided for in "C" below) shall be assumed as a longitudinal horizontal wind pressure of 20 pounds per square foot on cylindrical surfaces and 30 pounds per square foot on flat surfaces. On latticed structures, the exposed area shall be calculated as in Section 13. Consideration should be given to additional longitudinal loading due to one or more broken wires.

(b) Where there is an unbalanced load for any reason which will cause torsional stresses in excess of the stresses due to the longitudinal and transverse loading specified, such conditions shall be taken into consideration and adequate provision made for them.

(c) On anchor or dead-end structures, the longitudinal loading on poles, towers, bridges, foundations, crossarms, bracket arms, pins, insulators and attachments shall be the total pull of the catenary construction supported, the pull being taken as the tension in the wires and cable supported resulting from the loading specified in Sections 10, 11 or 12.

UNIT STRESSES AND FACTORS OF SAFETY

17. Tables of Permissible Unit Stresses and Proportion of Ultimate Strength

(a) Wood Supporting Structures

Material	Fiber Stress *Allowable Unit Stresses, Pounds per Square Inch, for* *Vertical, Transverse Angle and Dead End Loads*	*Longitudinal Loads*
Poles:		
Chestnut	1670	5000
Washington Cedar		
Idaho Cedar		
Port Orford Cedar		
Southern Red Cedar		
White Oak		
Bald Cypress (Heartwood)		
Yellow Pine		
Eastern White Cedar	1200	3600
Redwood		
Juniper		
Catalpa		

(b) Steel Supporting Structures

Material	Allowable Unit Stresses, Pounds per Square Inch, for Vertical, Transverse, Angle and Dead End Loads	Longitudinal Loads
Structural Shapes Tension (net section) or Bending	20,000	26,000
Compression (gross section)	*$18{,}000 - 80\frac{l}{r}$	$24{,}000 - 100\frac{l}{r}$
Steel Insulator Pins and Suspension Insulator Attachments, Tension or Bending	20,000	26,000

Rivets and Bolts	Shop Driven Rivets	Bolts and Field-Bolts Rivets	Shop Driven Rivets	Bolts and Field-Bolts Rivets
Shear	13,500	11,000	17,500	13,500
Bearing	27,000	22,000	30,000	27,000
Bending	20,000	16,500	20,000	20,000

(c) Concrete

Material	Allowable Unit Stresses, Pounds per Square Inch, for Vertical, Transverse, Angle and Dead End Loads	Longitudinal Loads
Mass Concrete 1:3:6 (Compression)	500	1,200
Reinforced Concrete 1:2:4 (Compression)	700	1,700
Reinforcing Steel (Tension)	20,000	26,000

(d) Tension in Conductors and Lightning Protection Wires

The tension in conductors and lightning protection wires shall not exceed the value specified in "Appendix 1, pages 68 to 72, of A.R.A. Specifications for the Construction of Overhead Electric Supply Lines for Railroad Use on Railroad Property." These values should be decreased for wires and cables subject to corrosion.

(e) Miscellaneous Items

The following items used in line construction shall not be stressed in excess of the proportion of their ultimate strength as tabulated below:

Messenger strand—ferrous	33%
Messenger strand—non-corrodable	50%
Guy strand	33%
Conductor attachments	50%
Insulator attachments	33%
Catenary hardware	50%
Catenary insulators	33%
Guy insulators—interlocking	50%
Guy insulators—non-interlocking	33%
Foundation and anchorages by uplift or overturning, including surrounding earth pressure	50%

*Limiting values of $\frac{l}{r}$ shall conform to provisions of Section 32D.

Wires and Cables

18. Material

All wires and cables should preferably be of material which will not corrode excessively under the prevailing conditions. Contact wire should be of hard drawn copper or bronze.

19. Minimum Sizes

The minimum sizes of conductors and cables shall be as follows:
Main line contact wire—single—3/0 AWG
Main line contact wire—double—2/0 AWG
Yard and siding contact wire—2/0 AWG
Galvanized steel strand—⅜"

20. Contact Wire Gradient

Contact wire gradient relative to the track shall approximate 0.5 to 1.0 per cent. It is desirable not to make gradient changes at low clearance points but rather adjacent to them.

Insulators

21. Porcelain Insulators

(a) Insulators made of porcelain shall conform to the requirements of the A.R.E.A. "Specifications for Porcelain Insulators for Railroad Supply Lines."

(b) Insulators or combinations of insulators shall have mechanical strength adequate to withstand the loads specified without exceeding 33 per cent of their ultimate strength.

(c) Due to their use in a traction circuit, one side of which is grounded, insulators shall have a dry flashover rating approximately 80 per cent greater than the requirements of the insulator specification. Where insulators used in a traction circuit one side of which is grounded, are installed above tracks jointly operated by steam and electric locomotives, insulators shall have a dry flashover rating approximately 180 per cent greater than the requirements of the insulator specification.

(d) Suspension insulators not in vertical suspension position, such as dead ends, shall have higher insulating values than similar insulators in vertical position due to the desirability of governing the location of flashovers (namely protecting dead ends from flashovers) and also of compensating for loss of insulating value on account of position in which used. Insulators in any position at strategic locations (station platforms, etc.) should, where desirable, have higher insulating values in order to prevent flashovers at those points.

22. Wood and Other Insulators

Insulators of wood or other approved material shall conform as nearly as possible to the requirements of the A.R.E.A. "Specifications for Porcelain Insulators for Railroad Supply Lines." They shall also conform to the provisions of Section 21-(b), (c) and (d) above. Wood stick insulators

may be used for the purpose of normally separating distribution circuits of the same potential from one another. Where conditions makes it desirable, wood may be used for insulation to ground.

Accessories

23.

In all cases where it is necessary to attach accessories or wires, or parts of accessories to each other, of dissimilar metals, care shall be taken by the insertion of sleeves that the resulting electrolytic action will be reduced so as not to weaken any essential part of the construction.

24. Hanger Rods and Wires

(a) In the longitudinal or track catenary, hangers may be of cable, tubing or solid metal, normally rectangular or round in section, which shall not corrode excessively under prevailing conditions. The minimum dimensions recommended for any section shall be ¼ inch in diameter for the round or $\frac{3}{16}$ inch for rectangular.

(b) In the cross span construction, hangers may be stranded cables or solid metal rods of such material as will not corrode excessively under prevailing conditions.

(c) Flexible cables or messengers—sometimes called "lacing cables"—may be used in place of hangers.

25. Clamps, Sockets, Turnbuckles, Miscellaneous Hardware

(a) Clamps and Sockets.—Clamps used with contact and messenger wires may be of either galvanized malleable iron or pressed or cast bronze with galvanized steel or bronze bolts and nuts.

(b) Sockets may be of bronze, mallebale iron or steel, the latter two galvanized, and may be attached to messengers by means of lugs cast on the end of the wire, or by compression of the socket about the wire or both. Fittings of this nature should be designed to develop at least the full strength of the wire with which they are used.

(c) Turnbuckles.—Turnbuckles shall be of bronze or galvanized steel of the split forging type.

(d) Insulator Attachments.—Attachment to strain insulators shall preferably be made by means of malleable iron, steel or bronze castings.

(e) Miscellaneous Hardware.—All miscellaneous hardware shall preferably be made of the same material as those parts of the construction with which it is associated. In all cases where the parts are of iron or steel, they shall be galvanized.

26. Section Breaks for Contact Wire

Section breaks for the purpose of sectionalization shall preferably be placed at major crossover locations and at substations. At all points where breaks are placed in the main line over through tracks, an overlapping air section break preferably should be used. Where it is difficult to install the overlapping air section break, such as over crossovers, yard tracks, or siding tracks, the non-overlapping type of break with metal gliders may

be used. The insulation used in both types of breaks may be wood, porcelain or other approved material.

27. **Switches**

Where the sections are not directly energized through substation circuit breakers, manually operated or remotely controlled switches with or without horn gaps, as the situation requires, shall be employed. Manually operated switches should preferably be designed to operate from the ground.

Strength of Supporting Structure

28. **Vertical and Transverse**

Each support shall have strength adequate to withstand the combined loads specified in Sections 14 and 15 without exceeding the allowable unit stresses specified in Section 17 for vertical, transverse, angle and dead end loads.

29. **Longitudinal**

Each support shall have strength adequate to withstand the loads specified in Section 16 without exceeding the allowable unit stresses specified in Section 17 for longitudinal loads.

30. **Any Direction**

(a) Each support shall have strength adequate to withstand the resultant forces due to any probable combination of assumed loads specified in Sections 14, 15 and 16 without exceeding the allowable stresses specified in Section 17 for longitudinal loads.

(b) At intervals, preferably not more than one mile, suitable anchorages for the catenary shall be provided. With bracket construction more frequent anchorages may be desirable.

Wood Structures

31. **Material**

Wood poles and beams shall be of chestnut, cedar or other selected material, reasonably straight, peeled and free from defects which will decrease their strength or durability. Poles shall have a nominal top diameter of not less than 7 inches.

32. **Depth of Setting**

Wood poles shall be set in the ground to depths not less than those shown in the following table:

Length of Poles	*Depth in Feet*	
Feet	*In Earth*	*In Rock*
25	5.0	3.0
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.0	5.0
60	7.5	5.0
65	8.0	6.0
70	8.0	6.0

Where located in soft or swampy ground, the setting of poles shall be suitably reinforced by setting in barrels of broken stone or gravel, or in stone or timber footings or by other equally effective methods. Where located in the side of banks or subject to washouts, foundations or pole settings shall be given additional depth or be protected by cribbing or riprap.

Where poles are subject to a continually unbalanced load, such as at angles in the line or dead ends and it is impracticable to install guys, methods of setting shall be employed that will develop the full required strength of the poles.

Back fillings for foundations or pole settings shall be carefully tamped or otherwise thoroughly compacted while being placed.

Steel Structures

33. Material and Designs

(a) Structural steel shall conform to the specifications A-9, "Structural Steel for Buildings," as adopted by the American Society for Testing Material.

The design and workmanship shall be in accordance with the best recognized practices.

Assembled members shall be free from twists, bends or other defects. Minor bends may be carefully straightened, but members having bends whose removal by field methods might injure the material, shall be replaced by new material. Mispunched holes shall not be subjected to excessive drifting. Bolting up wrenches of undue length shall not be used and care shall be taken to obtain tight bolts without overstraining the material thereof.

The form of the frame shall be such that stresses may be computed with reasonable accuracy. The construction, where practicable, shall be such that all parts are accessible for inspection, cleaning, and painting, and shall not have pockets in which water or dirt might collect. Where there are unavoidable pockets or depressions which would hold water, they shall have drain holes or be filled with waterproof material.

(b) The minimum thickness of metal shall be:

	Galvanized	*Painted*
Main members	¼ inch	$\frac{5}{16}$ inch
All other members	$\frac{3}{16}$ inch	¼ inch

Note.—Where members are subject to excessive corrosion, these values shall be increased proportionally. Attention is directed to the use of copper bearing steel for the retardation of corrosion.

(c) The minimum size of angles shall be 2 by 1¼ inches, and the minimum width of flats 1¾ inches. The minimum size of bolts and rivets shall be ⅝ inch in diameter. The diameter of rivet or bolt holes shall not exceed the nominal diameter of rivets or bolts by more than $\frac{1}{16}$ inch. The distance from the center of a rivet or bolt hole to a rolled edge or to a sheared edge shall be:

Diameter	*Distance from Rolled or Plane Edge*	*Distance from Sheared Edge*
For ⅝ inch	Not less than ¾ in.	Not less than ⅞ in.
For ¾ inch	Not less than 1 in.	Not less than 1⅛ in.

The minimum distance from center to center of rivet or bolt holes shall be one and three-quarter inch for five-eighth inch diameter and two and one-eighth inches for three-quarter inch diameter rivets or bolts.

(d) The unsupported length of a main compression member shall not exceed 150 times its least radius of gyration.

The unsupported length of a secondary compression member shall not exceed 180 times its least radius of gyration.

The unsupported length of a compression member which is introduced merely to reduce the unsupported length of a main or secondary member and, therefore, has no calculated stress, shall not exceed 200 times its least radius of gyration.

NOTE.—For slender guyed poles the above values may be modified.

34. Strength of Foundations

Both gravity type or "deep" side bearing type foundations for steel poles or towers shall withstand the vertical and transverse loads specified in Sections 14 and 15 without exceeding one-half of the ultimate strength or stability of the foundation. They shall withstand without failure the longitudinal load specified in Section 16.

For anchor or dead end structures, the foundations shall withstand the resultant forces due to the combined loading specified in Sections 14, 15 and 16 without exceeding one-half of the ultimate strength or stability of the foundations, including the surrounding earth pressure and weights.

In all cases where a steel pole acts merely as a vertical strut, the foundation shall be of such design as to prevent any settling and undue flexibility.

In designing foundations for poles and towers or anchorages for guys, the weight of concrete shall be considered as 140 lb. per cubic foot. The weight of earth, calculated at 30 degrees from the vertical, shall be considered in good ground, as 100 lb. per cubic foot. In swampy ground, special measure shall be taken to prevent uplift or depression.

The top of a concrete foundation or casing shall extend at least 6 inches above the surface of the ground, except where pavement or sidewalks make this impracticable, and in all cases should have sufficient slope to prevent collection of water.

CONCRETE STRUCTURES

35. Material and Designs

Portland cement concrete shall be used in proportion not less rich than one part Portland cement, three parts clean, sharp sand and six parts clean, hard broken stone, gravel or other approved aggregate. Water shall be clean, fresh and free from salts or other injurious impurities and used in such quantities as to obtain a quaking consistency.

Ample reinforcement shall be provided in the form of steel rods so as to take all strains set up in the completed structure except those of compression. The design of the structure shall be such that all reinforcement is completely covered by the concrete.

Guys

36. Strength of Guys and Anchors

(a) Guys, their anchors and attachments shall withstand the stresses imposed by the transverse loads specified in Section 15 without exceeding the proportions of their ultimate strength given in Section 17-(e). They shall withstand without failure the stresses imposed by the longitudinal loads specified in Section 16.

(b) Where guys are used to obtain the required strength in combination with wood or other flexible supports or concrete poles, the guys shall be considered as taking the horizontal component of the entire load, the pole acting as a strut, but subject also to simultaneous bending.

(c) Rigid steel structures should not be guyed except under special conditions in which case an investigation of the stresses should be made.

37. Materials for Guys

Guys shall be galvanized steel strand, or other material which will not corrode excessively under the prevailing conditions and shall have a minimum diameter of ⅜ inch.

38. Guy Anchorages

Guys to ground anchors shall be connected to a well anchored rod of such length that the eye of the rod will at least be one foot above the surface of the ground. Rods with a diameter of one inch or more need not be galvanized but should be protected below ground line by concrete jacket. The anchorages shall be at least as durable as the guys or guyed structures.

39. Location of Guy Attachments

(a) **Attachment to Structures.**—Guys shall be attached to structures as near as practicable to the center of the load to be resisted by the guy.

(b) **Location of Anchors.**—Guy anchors should, where practicable, be placed at a horizontal distance from the poles, measured at the ground line of not less than one-third of the height of the point of attachment of the guy to the pole.

(c) **Stub Guys.**—Guys from a structure to stub poles or to other poles shall be so placed and maintained that no part of any guy will come within eight feet of the ground.

(d) **Contact Between Guys.**—No guy shall be placed or maintained in contact with any other guy except where attached to the same pole, stub or anchor, nor in any case in contact with a metallic covered cable, suspension wire or ground wire.

40. Guy Insulation Requirements

(a) **Mechanical.**—Strain insulators in guys should preferably be of the interlocking type in which case they shall have a mechanical strength

at least equal to the required strength of guys in which they are installed.

When of the non-interlocking type, they shall have a mechanical strength not less than 50 per cent in excess of the required strength of the guys in which they are installed.

(b) Electrical.—Strain insulators or combinations of strain insulator in guys shall not flashover at twice the maximum normal line voltage to ground under uniform precipitation equivalent to one-fifth inch of rain per minute at an angle of 45 degrees to the axis of the insulator.

Where strain insulators are used in guys they shall be located not less than 8 feet above the ground nor less than 6 feet horizontally from the pole to which the guy is attached.

Where a guy passes above or below the conductors of another line, strain insulators meeting the requirements outlined in paragraph (a) above for the line guyed, and paragraph (b) above for the highest voltage concerned shall be installed in the guy between the two lines and at a horizontal distance of not less than four feet from the nearest conductor of either line, unless guy is effectively grounded.

Grounding

41. Grounding of Steel Structures

All steel structures shall be permanently and effectively grounded, preferably to the rail return circuit. This may be done by means of one or more overhead wires electrically bonded to the structure which shall be grounded to the rail return circuit by connection to the mid-point of impedance bonds. These wires may serve also as lightning protection wires. If impedance bonds are not used, it is preferable to ground each steel structure direct to the rail return circuit and to avoid all electrical connections between steel structures except those through the rail return circuits.

42. Grounding of Guys

Guys shall be permanently and effectively grounded or equipped with suitable strain insulators which meet the requirements of Section 40.

Appendix G

(7) COLLABORATION WITH COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

J. V. B. Duer, Chairman, Sub-Committee; D. J. Brumley, Vice-Chairman, Sub-Committee; H. M. Basset, J. C. Davidson, A. E. Owen, J. A. Peabody, H. M. Warren.

Up to the present time Sub-Committee No. 7 has not been called upon to co-operate with Committee XVI, and is holding itself in readiness to do so at such time as the latter Committee feels that co-operation is necessary and desirable.

Conclusions

It is recommended that the subject be continued.

Appendix H

(8) STANDARDIZATION OF FRICTION AND RUBBER TAPES

H. M. Warren, Chairman, Sub-Committee; R. Beeuwkes, Vice-Chairman, Sub-Committee; H. M. Bassett, J. H. Davis, C. B. Martin, J. L. Minick, M. Schreiber, G. I. Wright.

Certain minor changes in the wording of the Specifications for Friction Tape, as approved during the year 1925, have been suggested.

From correspondence with representatives of the Telegraph and Telephone Section, the Signal Section, and the Mechanical Division, it was found that the consensus of opinion was that no changes should be made in the specifications.

The suggested changes were discussed at the meeting of the Electrical Section on April 27th, 1927, and at that meeting it was decided not to approve the proposed revisions.

No other comments have been received.

Conclusions

That the subject of tape specifications be continued.

Appendix I

(9) STANDARDIZATION OF INSULATORS

F. D. Hall, Chairman, Sub-Committee; B. F. Bardo, Vice-Chairman, Sub-Committee; J. V. B. Duer, R. J. Needham, M. Schreiber, H. M. Warren, G. I. Wright.

Assignments:

1. Revise and keep up to date the Insulator Specification as adopted.
2. Consider the tensile strength of suspension type insulators as measured over a short period of time, as compared with the tensile strength as measured over a long period of time.

The following action has been taken:

1. The Sub-Committee is of the opinion that a revision of the Insulator Specifications is not called for at this time.

The Sub-Committee is represented on and is keeping in close touch with the work of the American Engineering Standards Committee, which has two Sectional Committees working on insulators.

The Sub-Committee recommends approval of the report of the Department of Commerce on One-Piece Porcelain Insulators, presented herewith, in the interest of elimination of waste.

2. The Sub-Committee has secured a limited amount of information covering the tensile strength of suspension type insulators, and has noted the increase in strength of the newer designs. It is of the opinion that there is not information of sufficient importance before it to justify a report this year.

Conclusions

It is recommended that this subject be continued.

SIMPLIFIED PRACTICE RECOMMENDATION NO. 73—ONE-PIECE PORCELAIN INSULATORS

In accordance with the unanimous action on June 3, 1927, of the general conference of representatives of manufacturers, distributers and users of One-Piece Porcelain Insulators, the United States Department of Commerce, through the Bureau of Standards, recommends that stock varieties of One-Piece Porcelain Insulators be limited to those listed in the following tables.

It is further recommended that stock varieties be specified wherever practicable.

These recommendations are to become effective for new production on October 1, 1927, subject to annual revision by a conference of the standing committee of the industry.

Promulgation recommended — R. M. Hudson, Chief, Division of Simplified Practice,

Promulgated — George K. Burgess, Director, Bureau of Standards.

LEGEND

(See also illustrations commencing on page 288)

Cook	—Cook Porcelain Insulator Corporation
Findlay	—Findlay Electric Porcelain Co.
Franklin	—Franklin Porcelain Co.
Gen. Porc.	—General Porcelain Co.
Hartford	—Hartford Faience Co.
Ill. Porc.	—Illinois Electric Porcelain Co.
Knox	—Knox Porcelain Corp.
Lapp	—Lapp Insulator Co. (Inc.)
Locke	—Locke Insulator Corp.
Ohio	—Ohio Brass Co.
Pinco	—Porcelain Insulator Corp.
Thomas	—R. Thomas and Sons Co.
West'house	—Westinghouse Hi Voltage Insulator Co.

SIMPLIFICATION OF ONE-PIECE PORCELAIN INSULATORS

HISTORICAL

The rapid growth of the electrical industry during the last quarter of a century, the improvement in methods of conducting electrical current over long distances, and the decided increase in demand for electric power for industrial and domestic purposes, have quite naturally led to the development of a large variety of sizes, types and dimensions of one-piece porcelain insulators. The industry concluded that this condition could be improved, and as a first step planned to determine which varieties of insulators represented the best thought and practice.

In requesting the co-operative services of the National Committee on Metals Utilization, the industry called attention to the prevalent over-diversification of their product, and pointed out that in the circumstances it was necessary for the manufacturers to spread their production and investment over a wide range of varieties, sizes and dimensions. The distributors of insulators, and of insulator pins as well, have to tie-up large amounts of capital in stocking their shelves to meet every possible demand, when the bulk of normal requirements could be satisfied by fewer varieties.

These considerations supplied the reason for the preliminary conference of porcelain insulator manufacturers which was called by the National Committee on Metals Utilization, on November 10, 1926. The conferees expressed the opinion that the elimination of superfluous varieties of insulators, based upon a knowledge of major demand, would benefit everyone. For the purpose of determining that demand, the conferees constituted themselves a Committee of the Whole, with Jay R. Palmer, of the Ohio Brass Company, as Chairman. It was decided that the scope of the survey should be confined to one-piece porcelain insulators.

The Committee of the Whole held a progress meeting in Washington on January 20, 1927. The Chairman presented a graphic layout of the various one-piece porcelain insulators as displayed in the current catalogs of the

MANUFACTURERS	FIGURE 1. STOCK CAT.NOS.	FIGURE 1. CAT.NOS. TO BE DISCOURAGED	FIGURE 2. STOCK CAT.NOS.	FIGURE 2. CAT.NOS. TO BE DISCOURAGED	FIGURE 3. STOCK CAT.NOS.	FIGURE 3. CAT.NOS. TO BE DISCOURAGED
Cook	10 15		20 129		155	
Findlay			186 192		182	180
Franklin					1000	
Gen. Porc.	109 112		136		133 134 144	155
Hartford					A-105	
Ill. Porc.	109 112	107 108	222 224		235	237
Knox	K-5 K-6		K-3		K-10	
Lapp	593				591-A	
Locke	8 9				44	
Ohio	9400 10565				10387	29207 9990
Pinco			499 799		62	325 359-L
Thomas	1011 1012		1094		1111	1101 1159
West'house	100 110				104	

MANUFACTURERS	FIGURE 4 STOCK CAT.NOS.	FIGURE 4 CAT. NOS. TO BE DISCOURAGED	FIGURE 5 STOCK CAT.NOS.	FIGURE 5 CAT. NOS. TO BE DISCOURAGED	FIGURE 6 & 6-A STOCK CAT.NOS.	FIGURE 6 & 6-A CAT.NOS. TO BE DISCRED.	FIGURE 7. STOCK CAT.NOS.	FIGURE 7. CAT.NOS. TO BE DISCOURAGED.
Cook	85		30	90	615		50	
Findlay	188		194		202		195	
Franklin	1033	1032	1011		1024	1001		
Gen. Porc.	2822	6-C	2904		145	3-C	151* 151#	
Hartford	A-106		A-107		A-100		A-108	
Ill. Porc.	253		247		256		257 261	
Knox	K-40		K-30		K-46		K-50	
Lapp	568		592				586	
Locke	8881	12	2		3749		396 3693	
Ohio	12847		5404		9953		12848 10636	
Pinco	491-L	61	223	674-L 623-L	264	645-A 645-L		
Thomas	1009		1010	1049	1108		1067 1177* 1196#	1164
West'house	146		136		106		166* 176#	

NOTE: * - 1 inch pin hole
- 1-3/8 inch pin hole

MANUFACTURERS	FIGURE 8 STOCK CAT.NOS.	FIGURE 8 CAT.NOS. TO BE DISCOURAGED	FIGURE 9 STOCK CAT.NOS.	FIGURE 9 CAT.NOS. TO BE DISCOURAGED	FIGURE 10 STOCK CAT.NOS.	FIGURE 10 CAT.NOS. TO BE DISCOURAGED	FIGURE 11 STOCK CAT.NOS.	FIGURE 11 CAT.NOS. TO BE DISCOURAGED
Cook	55		100	95			60	
Findlay	196	220			198* 199#		196-A	
Franklin	1002		1012 1013		1029 1031			
Gen. Porc.	43-C	131 140	2905* 2905#				168 2907* 2907#	
Hartford	A-109				A-110 A-111			
Ill. Porc.	361		259		366* 366#		266* 266#	235
Knox	K-55		K-49		K-55		K-60	
Lapp	564		587 590*	564#	582* 583#		585	
Locke	4451* 4451#		5-A 55		6510 6511		298	6512
Ohio	10044		9890 11913		12849* 12850#	25247.		
Pinco	366	300 622-L	645 645-A		64* 64-A#			
Thomas	1153		1022		1151 1152		1188* 1190#	1126
West'house	1311		156		1015* 1113#		1111* 1211#	1012* 1112#

NOTE: * - 1 inch pinhole
- 1-3/8 inch pinhole

MANUFACTURERS	FIGURE 12 STOCK CAT.NOS.	FIGURE 12 CAT.NOS.TO BE DISCOURAGED	FIGURE13 STOCK CAT.NOS.	FIGURE13 CAT.NOS.TO BE DISCOURAGED	FIGURE 14 STOCK CAT.NOS.	FIGURE 14 CAT.NOS.TO BE DISCOURAGED	FIGURE 15 STOCK CAT.NOS.	FIGURE 15 CAT.NOS.TO BE DISCOURAGED
Cook	910		65		70			
Findlay							114	
Franklin					1003 1123		1014	
Gen.Porc.	3045* 3045#		1-C* 1-C#		3050* 3050#		118	3060
Hartford					A-112 A-113		A-147	
Ill. Porc.	270* 270#		370* 370#		380* 380#		212	
Knox			K-65		K-70* K-70#			
Lapp					2063		588-A	
Locke	303#				6508 6509		6507	
Ohio					12851 12852	25118	10747	
Pinco			65* 65-A#		367* 367-A#		420-L	717-L
Thomas	1178 1179				1157 1158		1185	1140
West'house	1213* 1313#				1014* 1114#		120	

NOTE: * 1 - inch pinhole
- 1-3/8 inch pinhole

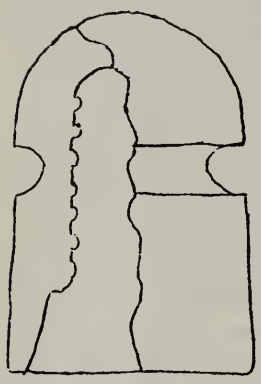


FIG 1.

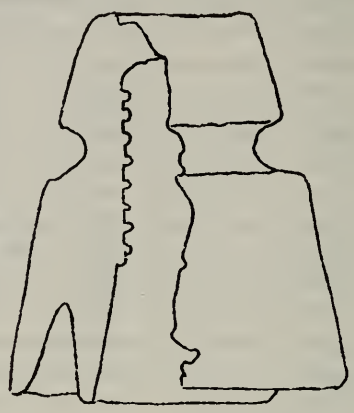


FIG. 2.

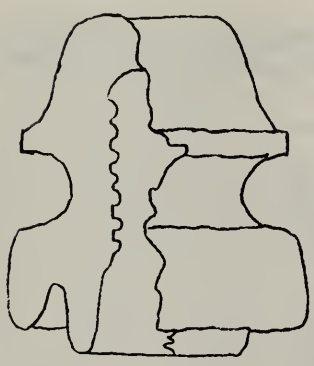


FIG. 3.

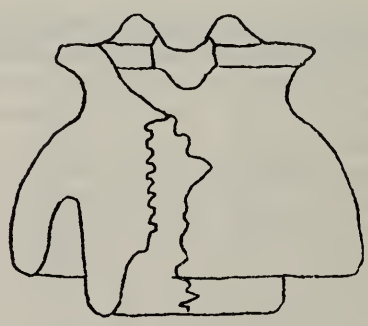


FIG. 4.

FIG. 5

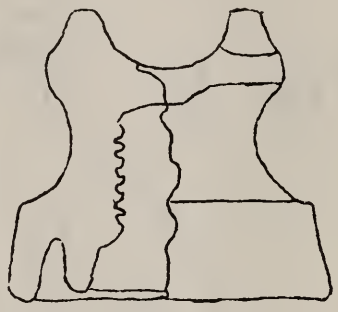


FIG. 6.

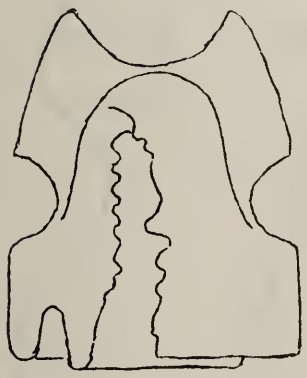


FIG. 6-A.

FIG. 7.

FIG. 8.

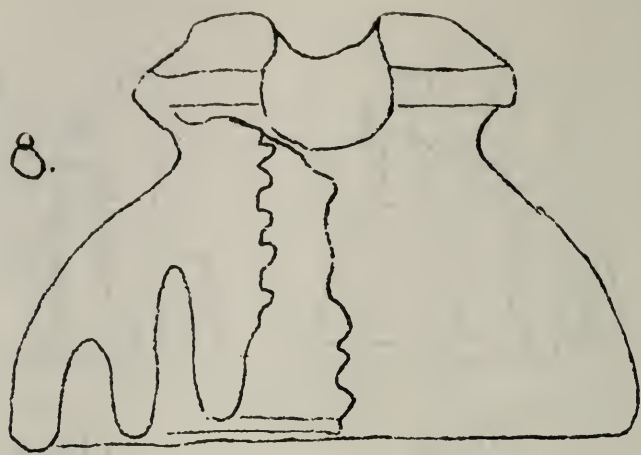


FIG. 9.

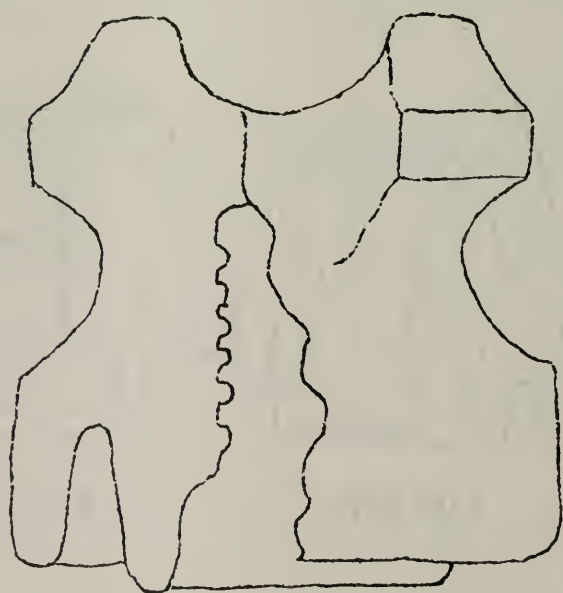


FIG. 10.

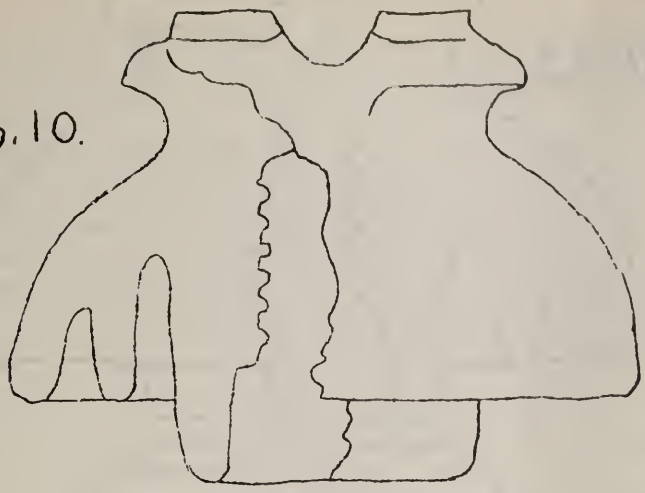


FIG. 11.

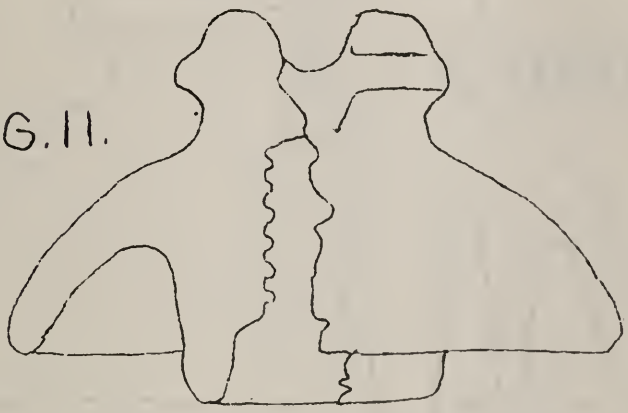
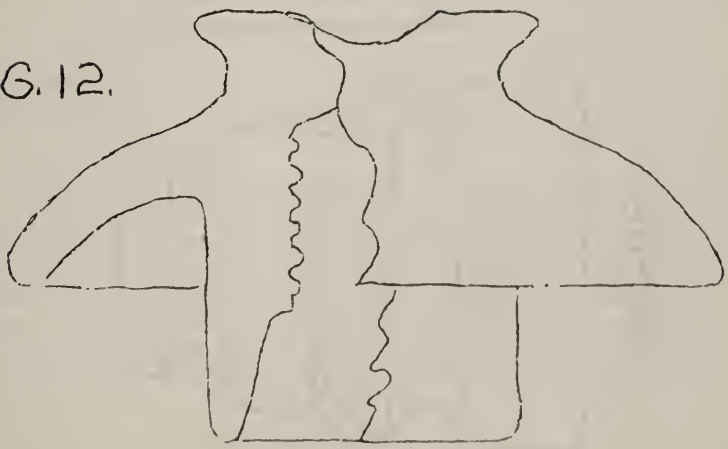


FIG. 12.



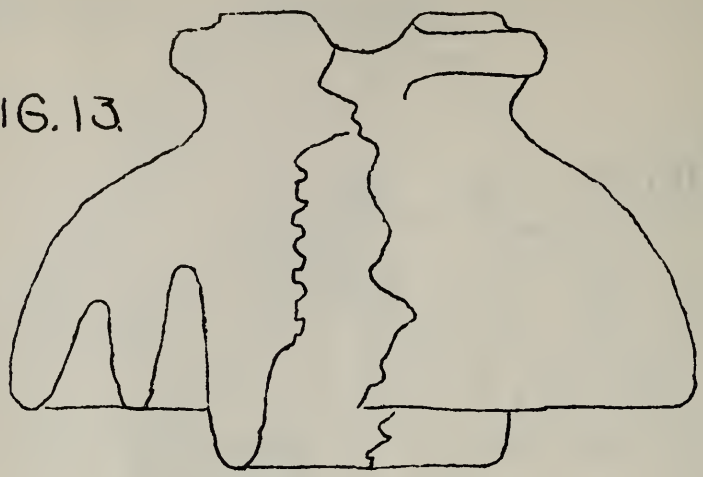


FIG. 13.

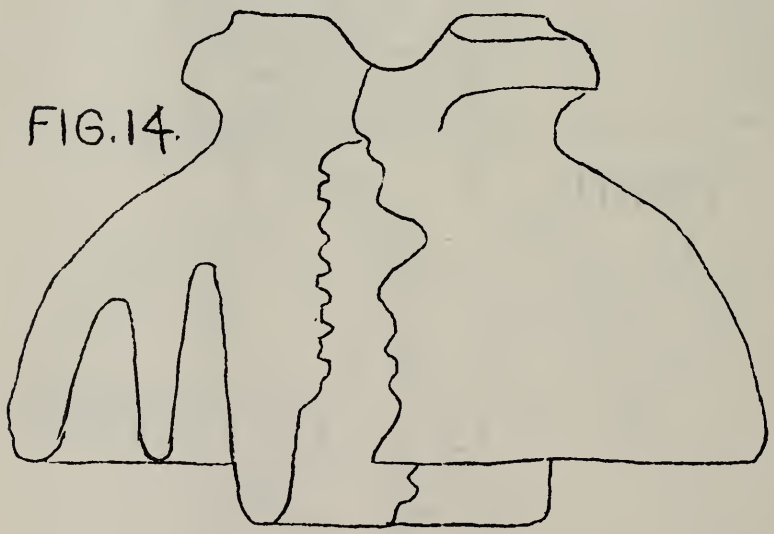


FIG. 14.

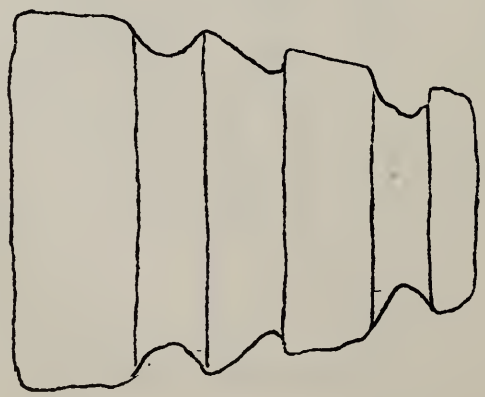


FIG. 15.

respective manufacturers. The available data served as a common denominator in designating those insulators which enjoy the greatest demand, and further served as a basis upon which to build a tentative Simplified Practice Recommendation.

Initially, the recommendation was in the form of tabulation which suggested the definite retention of certain insulators as stock items, and the elimination of certain other insulators which are seldom called for and therefore superfluous. A third classification, under the caption, "To be discouraged," was included in the tabulation for the following reason. As the adequacy of the recommended stock items becomes more and more firmly established, it will be possible to eventually eliminate those items which appear in the last-named category. The transitional period thus provided will insure that no one will be embarrassed or inconvenienced by too abrupt a change.

GENERAL CONFERENCE AT DEPARTMENT OF COMMERCE JUNE 3, 1927

With the survey completed, the Committee of the Whole requested the Department of Commerce to call a general conference of all interests to consider the tentative program, and formulate a definite Simplified Practice Recommendation for the guidance of all interests. On June 3, 1927, such a meeting was held, under the joint auspices of the National Committee on Metals Utilization and the Division of Simplified Practice.

Except for the retention of one catalog number which has been suggested for elimination, and one or two minor changes, the program was approved as it appeared in the agenda for the conference. In thus approving this program, the conference moved that it be suggested to all manufacturers of one-piece porcelain insulators that they in turn recommend to the trade (through their advertising media, catalogs and sales representatives), the adoption and use of the standards shown in Simplified Practice Recommendation No. 73.

The conferees were of the opinion that the consistent adherence of all concerned to this program would make possible an annual saving, to all interests, of approximately $400,000. It was further stated that a release of any fraction of the large amount of "frozen" capital that is tied-up in molds alone, would be decidedly welcome to everyone. If the burden of making and maintaining a large stock of molds can be removed from the shoulders of the manufacturers, a big step forward will have been taken to reduce costs all along the line.

While the conference frankly believed that further elimination could be made without embarrassing the industry, it is stated that this first application of the principles of Simplified Practice to porcelain insulators was sufficient in scope to bring the industry closer to the ultimate standards which will serve all interests best, at a minimum of expenditure. It was also the opinion of the conference that the successful operation of this program would not only pave the way for further eliminations, later on, but would also stimulate other branches of the electrical industry to similarly clear

out the superfluous varieties of many of its commodities. In this connection the chairman of the meeting directed attention to the fact that this project is the fourth to be passed through the regular procedure of the Department of Commerce by the electrical industry.

Pursuant to the request of the conference, the Department of Commerce will organize a standing committee of the porcelain insulator industry, whose function it will be to revise or otherwise review this recommendation annually, for the purpose of keeping the program thoroughly useful and abreast of existing conditions and advancement of the art of electrical insulation. The personnel of the Standing Committee will be made known at a later date.

RESULTS

The combined efforts of this general conference resulted in a reduction from a total of 272 varieties to 210 varieties of one-piece porcelain insulators, corresponding to an elimination of 22.4 per cent. The deletion of these varieties will take place in two stages. Twenty-three will be deleted on the effective date of this recommendation (October 1, 1927). The remaining thirty-nine will, in the course of time, gradually be dropped from production, for it is anticipated that the trade will progressively discourage their use, in favor of those varieties which satisfy the major demand.

As stated hereinbefore, this program holds a potential saving of $400,000 a year for all interests.

It is hoped that engineers, purchasing agents, works superintendents, standardization bodies, and all manufacturers, distributors and users of one-piece porcelain insulators will derive such tangible results from this Simplified Practice Recommendation that it will become desirable to extend the application of the principles of simplification to other items in the electrical field. Such practice should decrease stocks, production costs, selling expenses, misunderstandings, and all costs to the ultimate consumer.

Personnel of General Conference

Name	*Representing*
Anderson, George O.	General Porcelain Co., Parkersburg, W. Va.
Bishop, Fred L.	Hartford Faience Co., Hartford, Conn.
Dalgleish, R. H.	American Electric Railway Ass'n, New York.
Freeman, L. W.	Truscon Steel Co., Youngstown, Ohio.
Gilchrest, Geo. I.	Westinghouse Electric & Mfg. Co., Derry, Pa.
Holmes, H. R.	The R. Thomas & Sons Co., E. Liverpool, Ohio.
Hyde, W. A.	National Ass'n of Purchasing Agents, New York.
Kettron, C. W.	Illinois Electric Porcelain Co., Macomb, Ill.
Kirkwood, R. S.	War Department, Washington, D. C.
Maxwell, Alexander	National Electric Light Ass'n, New York.
Palmer, Jay R.	Ohio Brass Co., Mansfield, Ohio.
Patterson, Joseph V.	Findlay Electric Porcelain Co., Findlay, Ohio.
Snyder, Capt. W. K.	U. S. Marine Corps, Washington, D. C.

Department of Commerce:

Ely, Edwin W.	National Committee on Metals Utilization
Galt, A. B.	Division of Simplified Practice
Halsted, Arthur	Bureau of Standards.

Appendix J

(10) CLEARANCES FOR THIRD RAIL AND OVERHEAD WORKING CONDUCTORS

H. M. Bassett, Chairman, Sub-Committee; C. G. Winslow, Vice-Chairman, Sub-Committee; F. Auryansen, D. J. Brumley, F. D. Hall, A. E. Owen, W. M. Vandersluis.

Tables are presented herewith indicating up to date practice on electrified railroads for third rail and overhead conductor clearances. The data include information as to location of third rail above the plane of the running rail and beyond the gauge line.

Conclusions

It is recommended that this subject be continued.

Appendix K

(11) PROTECTION OF OIL SIDINGS FROM DANGER DUE TO STRAY CURRENTS

J. V. B. Duer, Chairman, Sub-Committee; Sidney Withington, Vice-Chairman, Sub-Committee.

The Sub-Committee has kept in touch with the Rules for Protection of Oil Sidings from Dangers Due to Stray Currents, recently adopted by the American Railway Engineering Association, with a view to determining whether changes are necessary.

So far no changes have been found to be necessary, but the Sub-Committee will continue to keep in touch with this situation with a view to recommending changes in the rules if, and when, they seem desirable.

Conclusions

It is recommended that this subject be continued.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Statement 1
Page 1

Data Regarding Third Rail Clearance

Name of Company	Top or Under Contact	Protection	Uses Steam Equipment	Structures Clear Prop Lines	Mileage in Operation	Mileage Planned for Immediate Future	Mileage Using Steam Equipment	Horizontal Distance Between Center of 3rd Rail & Gage Line of Nearest Running Rail	Vertical Distance Between Contact Plane of 3rd Rail with Top of Running Rail	Remarks
Baltimore & Ohio R.R. Co.	Top	Partly	Yes		7.96	None	7.96	30½"	3½"	Rail completely protected at Stations & partially protected at other points by guard boards 1" above rail.
Boston Elevated Ry.	"	No	No		48.739	8.837*	None	20 13/32"	5 15/16"	Partially protected * Being constructed by the City of Boston, will be paid for by the Rapid Ctn. By which differs from former practice of owned rather than leasing the tracks.
B-M Transit Corp.	"	About 48%	No		294.049	25.0	"	‡ 20½", 25"	‡ 6", 3½"	
Central California Traction Co	Under	Yes	Emergency Only	Yes	70.0	None	"	28½"	3"	24 Miles O.H. Trolley included in total.
Chicago, Aurora & Elgin R.R. Co.	Top	No	Yes	No	98.68	"	98.68	20½"	6 5/16"	4½ Miles O.H. Trolley included in total.
Chicago Rapid Transit Co	"	"	No	"	227.49	"	None	20⅛"	6½"	24 " " " " " "
Eastern N.Y. Utilities Corp. (formerly Albany Southern R.Co.)	"	"	"	Yes	49.62	"	"	27¼"	5¼	1 Mile " " " " "
Grand Rapids, Grand Haven & Muskegon Ry Co	"	"	"		46.0	"	"	20⅝"	5¾"	10 Miles " " " " "
Hudson & Manhattan R.R. Co	"	Yes	"	No	20.0	"	"	26"	4"	Subway
Interborough Rapid Transit Co	"	"	"	"	386.68	25.0	"	26", 20¾", 27" **	4", 7½", 4" **	Subway and Elevated Lines
Lackawanna & Wyoming Valley R.R.	"	No	Yes	"	52.0	None	52.0	19"	3¾"	10 Miles O.H. Trolley included in total
Long Island R.R. Co.	"	Yes	"		330.0	Approx 145.0	330.0	26"	3½"	97.1 " " " not " " "
Michigan Central R.R. Co.	Under	"	"	Yes	28.55	None	26.55	28¼"	2¾"	2.7 " " " included in total
Michigan R.R. Co.	Top	No	"		117.39	"	117.39	31"	8¼"	O.H. & Underground Conductors at Crossings

Revised Nov 1. 1927

‡ Old and new respectively.
** Subway Div. Manhattan Div and where both are operated, respectively

63500

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Data Regarding Third Rail Clearance

Statement 1
Page 2

Name of Company	Top or Under Contact	Protection	Uses Steam Equipment	Structures Clear Prop Lines	Mileage in Operation	Mileage Planned for immediate future	Mileage Using Steam Equipment	Horizontal Distance Between Center of 3rd Rail & Gage Line of Nearest Running Rail	Vertical Distance Between Contact Plane of 3rd Rail with Top of Running Rail	Remarks
New York Central R. R. Co	Under	Yes	Yes	Yes	320 9	Approx 60.0	273 6	28 1/4"	2 3/4"	2.375 Miles O.H. Conductors
New York State Rys.	"	"	"		105 1	None	103 18	32"	2 3/4"	
Northwestern Pacific R R Co	Top	Sta's only	"		38 49	"	38.49	27 3/4"	6"	
Pennsylvania R.R. (New York Div)	"	Yes	"	Yes	106 56	"	22 70	# 27 3/8", 27 13/16"	3 1/2"	1 18 Miles O.H. Contact at X-overs in N Y Station
Penna R.R. (West Jersey & Sea Shore)	"	"	"		150 30		150 30	26"	3 1/2"	8 61 Miles O.H. Trolley included
Philadelphia & Western Ry. Co.	"	"	"	Yes	37 15	None	None	26"	3 1/2"	9 Miles O.H. Trolley Yds. & Sidings not in total.
Philadelphia Rapid Transit Co.	Under	"	No	No	34 673	"	"	27"	6"	Subway & Elevated Lines
Puget Sound Electric Ry.	Top	No	"	"	57. 68	"	"	20"	7 1/8"	18 57 Miles O.H. Trolley included in total
Sacramento Northern Ry	"	Sta Grounds	Emergency Only	"	217 87	"	"	27 1/2"	5 9/16"	55 03 Miles O.H. Trolley included in total
Scioto Valley Traction Co	"	No	No	Yes	75 11	"	"	28"	6"	6 81 " " " " " "
Staten Island Rapid Transit Ry	"	Yes	"	"	43 63	"	"	27 9/16"	3 1/2"	All passenger service electrically operated
Wilkes-Barre & Hazelton Ry. Co	"	"	"	Slight	30 74	"	"	28"	5 1/16"	1 54 Miles O.H. Trolley on Lehigh Traction Co. not in total

27 3/8" with 25# 3rd rail
27 13/16" " 150# " "

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Statement 2
Page 1

Data Regarding Overhead Clearance

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip. Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Bangor Hydro-Elect. Co.	2/0 B and O	Max. 23'-0" Std 19'-0" Min 15'-0"	67.69	A few freight cars	None Submitted	D.C. 600	Trolley	None	
Boston & Maine R.R.	4/0 Grooved	Std 22'-0" Min 16'-3"	21.385	21.385 Mi.	Submitted	Single Phase A.C. 11.000	Pantagraph	Print Submitted	Berkshire St. Ry at No. Adams 19'-1" 16'-3" Standard for Hoosac Tunnel
British Columbia Elec. Ry. Co.	4/0 Grooved & Round	22'-6"	158.72 Mi Inter 19.14 " City	None		D.C. 550-600	Trolley	None	Steam Road Equipment handled in daily Inter-Change of Freight Freight handled by Elec Locomotives
Brooklyn City R.R. Co.	2/0 Round	19'-0"	208.5	"		D.C. 600	"	"	
B.M.T. System	Round 1/0-3/0-4/0	Max 21'-6" Std 18'-0" Min 12'-0"	314.48	See Note	Outline of Equipment	D.C 575	"	"	Freight handled by Elec. Loco.
Butte, Anaconda & Pacific Ry. Co.	4/0 Grooved	Max 22'-0" Std 22'-0"	122.89	28.78 Mi.	Outline of cars and locomotives	D.C 2400	Pantagraph		Catenary Construction
Canadian National Rys. (St. Clair Tunnel)	4/0 & 300.000 C.M Grooved	Max 22 in Yds. Min. 15'-4" Tunnel 16'-6"	12.0	About 10 Miles	Submitted	Single Phase A.C 3300	"	None	Handles Std. Frt. & Pass. Equip. in terminals and thru tunnel international service.
Cedar Rapids & Iowa City Ry.	4/0	Max 22'-0" Avg 19'-0"	45.7	5 Mi.	"	D.C 600	Trolley	Yes	Main Line only. 17 Mi Catenary Balance direct suspension. Freight handled by Elec Locomotives
Central Illinois Public Ser	4/0	Max 22'-0" Avg. 18'-0"	15.13	All freight	None Submitted	D.C 1200	"	None	
Chicago South Shore & South Bend R.R.	4/0 Grooved Bronze	Max 23'-0" Std. 22'-0" Min. 15'-6"	155.1	155.1	Submitted	D.C. 1500	Pantagraph	"	Freight handled by 7 Elec Locomotives
Chicago, Milwaukee & St Paul Ry. Co.	4/0 Grooved	Std 24'-2"	861.49	None	None Submitted	D.C 3000	"		668.9 Mi 1st Main - 4.59 Mi. 2nd Main 188.0 Mi. Siding and Yard
Chicago, North Shore & Milwaukee R.R. Co.	3/0-4/0 Grooved	Max. 23'-0" Std. 22'-0" Min. 14'-9"	255.88	Yes	None Submitted	D.C. 600	Slider Shoe & Trolley wheel	Catenary	Freight handled by Elec Locomotives
Cincinnati, Georgetown & Portsmouth R.R	3/0 4/0 Grooved	Max 22'-0" Avg 19'-0"	62.0	None	None Submitted	D.C 600	Trolley	None	Freight Equipment Interchanged
Clinton, Davenport & Muscatine Ry Co	3/0-4/0 Round	No Standard's in State	66.0	" "	None Submitted	D.C 600-1200	"	Double Spans Heavy Poles Back Guys	Catenary Construction 25 Miles
Detroit United Lines	2/0-3/0 Grooved Round & B	Max 22'-6" Std 18'-6" Min. 14'-6"	613.9	A few freight cars	Std Line Construction	D.C 600	"	According to Specifications of Michigan Ry. Comm	" " 20 "

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Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip. Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Erie Railroad Co	3/0 Grooved	Max. 24'-0" Std. 22'-0" Min 16'-0"	38.0	34.0	None Submitted	11.000	Pantagraph	None	Operates Standard Steam Engines for Freight
Evansville Suburban & Newburgh Ry Co.	3/0 Grooved	Max. 22'-0" Avg. 18'-0"	25.0	25 Mi	None Submitted	D.C. 600	Trolley	22' Height at X-ings required by State Law	Operates standard freight cars with steam locomotives
Fonda, Johnstown & Gloversville R.R. Co	4/0 Grooved	Max. 22'-0" Std 18'-0" Min 15'-0"	78.0	½ Mi	None Submitted	D.C. 600	"	22' Height at Steam X-ings.	
Fort Dodge, Des Moines & Southern R.R. Co.	3/0 - 4/0 Grooved	Max. 24'-0" Std. 23'-0" Min. 21'-0"	150.0	150 Mi.	None Submitted	D.C 1200	"	None	Handles Std Freight Cars with Electric Locomotives.
Galveston Electric Co	2/0 Round	Max. 22'-0" Std. 18'-0" Min. 17'-0"	34.76	None	None Submitted	D.C. 650	"		
Grand River Railway Co.	4/0 Round 2/0 Round	Max. 22'-6" Avg 18'-6"	22.0	½ Mi	None Submitted	D.C 1500	"	22'-6"	Std. Freight & Pass. Equip. handled with Elec. Locomotives and 2 occasionally by Steam
Great Northern Ry Co.	3/0-4/0 * Grooved 1" C to C	Max. 24'-0" Min 17'-6"	31.7	31.7 Mi.	None Submitted	5 Phase 25 Cycle D.C. 11500 V	Pantagraph	None	Includes 25.5 Mi. Main Line Min Height in Tunnels
Illinois Traction System (Main Div.)	3/0 Grooved	Max. 23'-0" Std. 20'-0" Min. 15'-6"	505.15	None	None Submitted	D.C. 600	Trolley	As per State Comm Rules For Height only.	Handles Standard Cars but no locomotives.
Illinois Traction System (Illinois Valley Div.) (Formerly Chicago, Ottawa & Peoria Ry.)	3/0 8 & Grooved	Max 22'-6" Avg. 18'-0"	106.56	None	Submitted	D.C. 650	"	Yes	Steam Road Equip. handled in daily interchange of Freight
Interstate Public Service Co.	4/0 Grooved	Max. 21'-0" Avg. 18'-0"	117.6	"	None Submitted	D.C. 600	"	Elevated Trolley wires to clear legal requirements	Exchanges Equip (Pass & Freight) with other Electric Lines
Illinois Central R. R. Co. (Chicago Terminal)	3/0 - 4/0	Max. 23'-0" Min. 16'-6" Norm. 22'-0" and 18'-6"	123.0		Submitted	D.C. 1500	Pantagraph	Yes	Suburban service only. Put in operation in 1926.
Indiana, Columbus & Eastern Traction Co	4/0 Grooved & Round	Max. 22'-0" Std. 21'-0" Min. 16'-0"	152.02	None	See Note	D.C 600-650	Trolley	A.E.R.E Assn.	Bldgs. 10' from ℄. 152.02 Miles owned Track age rights 2.88 Miles. Joint owned .33 Miles
Joplin & Pittsburg Ry. Co.	4/0 0 & 8 2/0 0	Max. 22'-0" Avg. 19'-0"	104.0	"	None Submitted	D.C. 600	"	22' Wire Clearance	Handles Std Equip. in Interchange with Steam Roads.
Kansas City, Clay County & St. Joseph Ry Co	4/0 Grooved	Max. 23'-0" Avg. 19'-0"	70.0	See Note	None Submitted	D.C. 1400	"	22' Height at Steam X-ings.	Freight Equipment interchanged
Lake Erie & Northern Ry.	4/0 Grooved	Max 22'-6" Std. 21'-6" Min 16'-6"	52.8	½ Mi.	Submitted	D.C. 1500	"	22'-6"	Std. Frt. & Pass. Equip. handled with Elec Loco. & Occasionally by Steam

* 3/0 Side Tracks
4/0 Main Line

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Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X'ings, other Roads	Remarks
Lake Shore Electric Ry Co	4/0 Grooved	Max. 22'0" Std 18'0" Min 16'6"	218.0	7 Mi	All New Work	D C 600	Trolley Shoe Wheel	None	Trolley raised to 22
Lehigh Valley Transit Co	2/0 - 4/0 Round & B	Std 18'6"	196.3	None	None Submitted	D.C 600	Trolley Shoe Wheel		
Lima Toledo R R Co	3/0 Round	Max 22'0" Std 21'0" Min 18'0"	707	None *	None	D C 600	Trolley	None	* In past we have handled stone in Steam Cars
London & Port Stanley Ry	4/0 Catenary	Max 23'2" Min 16'0"	24.6	24.6 Mi	None Submitted	D C 1500	Pantagraph	Yes	
Mason City & Clear Lake R R Co	2/0 Round	Max 23'0" Min 21'0"	20.6	None	None submitted	D C 650	Trolley	None	Interchanges Freight Equip with Steam Roads
Minneapolis, Anoka & Cuyuna Range Ry Co	4/0	Max 22'0" Std 21'0"	18.1	"	None Submitted	D C 650	"	None	Freight Division
Michigan Electric Ry Co	4/0 Grooved	Max 22'0" Min 18'0"	45.56 Main 2.68 Siding	Yes		D C 650	"	Double Support	Total of 150.26 Mi of which 48.24 Mi is Overhead and 102.02 Mi is 3rd Rail
Montreal & Southern Counties Ry Co	4/0 Grooved	Max 23'0" Std 22'0" Min 15'0"	53.66	None	None Submitted	D C 600	"	None	Interchanges Freight Equip with Steam Roads
Mt Royal Tunnel & Terminal Ry (Canadian National Rys)	4/0 Catenary	Max 23'0" Min 16'0"	32.2	10 Mi	None Submitted	D C 2400	Pantagraph	Yes	Steam used on Electrified Tracks, in part
New York Central R R Co. (Overhead)	8 & 3	Sh 44.5% Mu 44.5% Max 15'3" 15'5" Min 15'1" 15'3"	2.375	.071 Mi		D C 660	Shoe	None	Running Position 15'1" Low 14'7 7/8" to 14'9 1/2" High (N Y C) 15'5 7/8" to 15'6"
N.Y. N.H. & H. R R. Co (Main Line)	4/0 Grooved	Max 23'0" Std 20'3" & 22'0" Min 15'6"	573.0	560.5 Mi	Submitted	A C 11.000	Pantagraph	Yes	Includes 24 Mi on New York Connecting R R
N.Y. N.H. & H. R. R. Co (N.Y.W. & B.)	4/0 8	Max 23'0" Std 22'0" Min. 16'0"	62.8	None	"	A.C. 11000	"	None	
N.Y. N.H. & H. R. R. Co (P.W. & B.)	4/0 Round	21'0"	48.5	48.5 Mi.	"	D.C. 650	Trolley	Yes	Sliding Contact
N.Y. N.H. & H. R. R Co (Nantasket Beach)	4/0 - 6/0 8	21'0"	16.61	16.61 Mi.	"	D C 600	"	None	" "
N.Y. N.H. & H. R R Co (Berlin - Middletown)	4/0 Round	22'0"	10.88	10.88 Mi	None Submitted	D.C. 600	"	None	

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Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X'ings, other Roads	Remarks
New York State Railways	2/0-3/0-4/0	Max 22'0" Std. 20'0" Min 18'0"	493.97	None	Submitted	D.C. 575-650	Trolley	None	22' Std on Electric Steam Roads and R.R. X'ings. 18'-20' Std on Trolley or City Lines
Niagara St. Catharines & Toronto (Canad. an National Electric Rys.)	4/0 Grooved	Avg. 22'-6" Min 18'0"	104.29	88.74 Mi		D.C. 600	"		32.8 Mi. of Sidings & Spurs included
Norfolk & Western Ry. Co.	3/0 Grooved	Std 24'0" Min 17'6"	208.51	208.51 Mi	Submitted	A.C. 11.000	Pantagraph	See Note	Foreign Lines are required to cross using steel poles and giving 60' clearance above rails.
Norfolk Southern R.R. Co.	4/0 Grooved	Max 21'0" Std 21'0" Min. 19'4"	42.30	42.30 Mi	Submitted	D.C. 550 A.C. 13.200 60 Cycle	Trolley		
Northern Ohio Power & Light Co.	3/0-4/0 Grooved	Max. 22'0" Std. 18'0"	290.50	None	None Submitted	D.C. 600	"	Max height at R.R. X'ings.	22 feet
Northern Texas Traction Co	2/0-3/0-4/0	Max 23'0" Avg. 19'0"	146.771	None	None Submitted	D.C. 600	"	None	
Orleans Bradford & Salamanca Ry Co. (Formerly Western N.Y. & Pa. Traction)	4/0 Round	Max. 22'0" Min. 18'0"	85.00	None	None Submitted	D.C. 650	"	None	Interchanges Frt. Equip with 4 Steam Roads
Oregon Electric Ry.	4/0 Grooved	Max 23'0" Std. 22'0" Min. 16'0"	195.94	None	None Submitted	D.C. 10 Mi. - 600 V 185.94 Mi. - 1300 V	"	Yes	
Pacific Electric Ry Co.	3/0-4/0 Grooved	Max 22'0" Min. 19'0"	1168.02	956.78	Submitted	D.C. 600 & 1200	"	Insulated X'ings	
Pacific Northwest Traction Co	2/0 to 4/0 Round 2/0 Grooved 4/0	Max. 21'0" Std. 20'0" Min 19'0"	66.41	66.41 Mi	Submitted	D.C. 600	"	23' Clearance over Steam Lines	Includes Northern and Southern Division
Pennsylvania R.R. Co. (New York Div.)	25 lb. Rail "T" Shape	Max. 15'5" Std. 15'4" Min. 15'2"	1.18	None	Submitted	D.C. 650	Pantagraph	None	Used at X'overs in N.Y. Station
Pennsylvania R.R. Co. (Phila Paoli, Chestnut Hill)	3/0 Grooved	Max 24'0" Std. 22'0" Min 15'7¼	125.40	125.40 Mi.	Submitted	Single Phase A.C. 11.000	"	None	Also includes Ft. Washington Branch
Pennsylvania R.R. Co (West Jersey & Seashore)	4/0 Grooved	Max. 22'0" Std. 22'0" Min. 22'0"	8.65	8.65 Mi.	Submitted	D.C. 675	Trolley	None	
Pennsylvania R.R. Co (Cumberland Valley)	4/0 Grooved	Max 22'2" Std 22'0" Min 16'8"	9.06	9.06 Mi.		D.C. 550	"	None	
Pennsylvania R.R. Co. (Williamsport)	3/0 Grooved	Max 22'0" Std 22'0" Min. 15'9"*	0.47	0.47 Mi.	Submitted	D.C. 550	Trolley	None	* Trolley wire on Lewisburg Bridge

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Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip. Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Portland Electric Power Co. (Formerly Portland Railway Light & Power Co.)	1/0-3/0-4/0 Grooved & B	Interurb. City Max 22-0 21-0 Avg 21-0 19-0	315 61	None	Submitted	D.C 600	Trolley	Insulated X-ings	190.68 Mi City Lines Owned 16.741 " " " Operated, not owned .868 " Interurb " partly owned 113.810 " " " owned & operated, not owned .821 " " "
Puget Sound Electric Ry	4/0 Grooved	Max 22'-0" Avg 19 0	57 68	"	Submitted	D.C. 600	"	Trolley Height 22'-0"	39 11 Miles 3rd Rail 18.57 " Trolley
Quebec Railway Light Heat & Power Co.	2/0 Round	Max 22'-0" Min 19-0"	46 89	46 89	None Submitted	D C 550	"	Built according to Spec of Canadian Ry Comm.	
Rock Island Southern Ry. System (Galesburg & Western R R)	3/0 B & Grooved	Max 22'-0"	15.0	None	None Submitted	D C 600	"	None	
Sacramento Northern Ry (Formerly Northern Elec Ry)	4/0 - 2/0	22'-0"	55 03	None	Submitted	D C 600	Trolley*		* Pantagraph on Locomotives Trolley on Motor Cars
Salt Lake & Utah R R Co	4/0 Grooved	Max 22'-0" Std 22'-0" Min 18'-0"	92.0	None	Submitted	D C 1500	Trolley	See Note	By contract or under tentative general order of Public Utilities Comm. of Utah effective Sept 1, 1917
San Francisco Napa & Calistoga Ry.	3/0 Grooved	19'-0" New Curves 22 0"	45 31	7 Mi	Submitted	A C 3300	Pantagraph	Genl Order 64 C R C	22 Trolley Clearance on Reconstruction or New Work
San Francisco Sacremento R R	4/0 Grooved	Max 22'-0" Std 20'-0" Min. 19'-0"	103.0	None	Submitted	D C 1200	Trolley	None	Height of Trolley Clearance now 22', minimum in this State for all new construction
Southern New York Ry Inc.	2/0	Avg 18 0"	68 0	None	None Submitted	D C 600	"	Yes	Handles Std Frt Equip. over entire mileage -
Southern Ohio Public Service Co.	4/0 Grooved * Round	Max. 22'-0" Std 21'-0" Min 16'-0"	85.1	None	See Note	D.C 600 to 650	"	A.E.R.E Assn	Pole line 8' & Bldgs 10' from ℄ of track
Southern Pacific Co (East Bay Elec Div.)	4/0 Grooved	Max 22'-0" Std 22'-0" Min 18'-0"	* 118 07	× 56 Mi	None Submitted	D C. 1200	Pantagraph	Double Insulation with grounded Section	* Includes 19.73 Mi Sidings & Spurs × Includes 12 8 Mi Sidings & Spurs
Southern Pacific Co. (Portland Div.)	4/0 Grooved	Avg 22'-0"	* 172.45 + # 18 34 Mi of 31 Car Lines	× 137 01 Mi	Submitted	D C 1600	"	Double Insulation with ungrounded dead Section	* 17 31 Mi. Sidings & Spurs & 1.43 Mi 2nd Track # .30 Mi 2nd Track × 14 21 Mi. Sidings & Spurs
Spokane, Coer d'Alene & Palouse Ry Co	3/0-4/0 B & Grooved	Max 22'-0" Avg 19'-0"	184 4	None	None Submitted	A.C 6600 D C 600	Pantagraph Trolley	None	
Tacoma Ry. & Power Co	2/0 Round	Max 22'-0" Avg. 19'-0"	103.12	None	None Submitted	D C 600	Trolley	Trolley Height 22'-0"	Includes Pacific Traction Co
Tarrant County Traction Co.	4/0 Grooved	Max 23'-0" Std 19'-0" Min 17'-0"	29 841	None	None Submitted	D C 600	"	National Trolley Guards	

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Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip. Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Texas Electric Ry.	4/0 Grooved	Max. 23'-0" Std. 19'-0" Min. 17'-0"	229.94	None	None Submitted	D.C. 600 & 1200	Trolley	National Trolley Guards	Interurban Main Line
Toledo & Western R.R. Co.	3/0 - 8 4/0 Round	Max. 27'-0" Std. 21'-0" Min 18'-0"	73.5	None	None Submitted	D.C. 600	"		Interchanges Frt. Equip with Steam Roads
Toronto Suburban Ry. (Canadian Natl. Elec. Rys.)	4/0 on Main Line Catenary & 2/0 on Sidings	MAIN LINE Avg. 20'-0" Min. 19'-0" Min 15'-2" *	48.36	48.36 Mi.		Main Line 1500 Shop Yards 600 Guelph Entrance 600	"		* Min. under Bridges 15'-2" Sidings, Wyes, etc. 4.16 Mi.
Twin City Lines (Minneapolis, Minn.)	3/0 Grooved	Max 22'-6" Std. 18'-0" Min 17'-0"	9135 Interurban 414.88 City	None	None Submitted	D.C. 600	"	22'-0" Trolley above Steam Road Tracks	
Union Traction Co. of Indiana	1/0-2/0-3/0 Round-8 & Grooved	Max 22'-0" Std. 18' to 20' Min 15'-8" Bridges	403 Interurban 38 City	1 Mi.	Submitted	D.C. 600 To 650	"	Trolley 22' above Steam Road Tracks Double Span wires	
United Electric Rys. Co. (Formerly Rhode Island Co.)	2/0 - 4/0 Round & Grooved	Max 22'-0" Std 19'-20' Min. 13' under Br.	320.0	None	None Submitted	D.C. 600	"	Double span 1 each side of crossings & trolley guards	With catenary construction
Utah Idaho Central R.R. Co.	2/0 - 4/0 Grooved	Interurban 22'	130.4	None	As per Railway Line Clearance & Bridge	D.C. 750-1500	"	Yes	Interurban Lines
Utah Rapid Transit Co.	2/0 - 4/0 Grooved	18'-0"	28.38	None		D.C. 600	"	Trolley Height 20'	City Lines
Virginian Railway Co	3/0 Grooved	Max 24'-6" Std. 24'-6" Min. 18'-0"	228.02	261.52 Mi.	None Submitted	A.C. 11.000	Pantagraph	None	
Visalia Electric R.R.	3/0	22'-0"	51.8	19.86 Mi.	None Submitted	A.C 3300	Pantagraph	None	Interchanges Equipment with Steam Lines.
Walla Walla Valley Ry Co.	4/0	21'-0"	30.3	24.4 Mi.	None Submitted	D.C 600	Trolley	22' Wash. 23' Ore	Interchanges Equipment with Steam Roads
Washington, Baltimore & Annapolis Elec. R.R. Co.	4/0 Grooved	Max. 21'-0" Std 19'-0" Min 15'-0"	137.1	22.0 Mi.	None Submitted	D.C. 1200	"	None	
Washington & Old Dominion Ry.	4/0 Round Grooved	Max. 22'-0" Std. 21'-6" Min 16'-0"	88.3	None	None Submitted	D.C 650	"	None	
Waterloo, Cedar Falls & Northern Ry. Co	4/0 Grooved 2/0 Round	Interurb Max. 23'-0" Std. 21'-0" Min 15'-0" / City Max. 22'-0" Std. 18'-6" Min 18'-0"	138.67	117.54 Mi.	None Submitted	D.C. 650-1300	"	A.E.R.E.A. Std. Specifications	Interchanges Frt. Equip. with Steam Roads.
Western Ohio Ry. Co.	2/0 Round 3/0 Grooved	Max. 22'-0" Min. 18'-0"	112.0	None	None Submitted	D.C. 650	"	None	
Youngstown & Suburban Ry Co.	3/0 Grooved	Std. 17'-6"	20.0	None	None Submitted	D.C. 625	Trolley	None	

Appendix L

(12) SPECIFICATIONS FOR TRACK AND THIRD RAIL BONDS

J. H. Davis, Chairman, Sub-Committee; J. V. B. Duer, Vice-Chairman, Sub-Committee; F. Auryansen, E. B. Kattee, A. Knapp, J. A. Peabody, J. T. Seaver, W. M. Vandersluis, L. S. Wells, R. P. Winton, S. Withington

Five subjects were assigned to the Sub-Committee for study and inclusion in its report as follows:

1. Developing a standard specification for measurement of bond resistance.
2. Securing data on current carrying capacity of bonds.
3. Study of details of bond design with a view to developing specifications covering the different classes of bonds.
4. The effect of heat of welded bonds on track rails, co-operating with the Rail Committee.
5. Means of attaching bonds to manganese track rails.

(1) Specification for Measurement of Bond Resistance

Rail bond resistance is measured in ohms and in equivalent rail feet or the ohmic resistance divided by the resistance per foot of rail.

The resistance of a bond is governed by the cross-sectional area and length of the bond and the contact resistance of the terminals. The contact resistance of stud terminal bonds is the resistance of the contact of the terminal stud with the wall of the rail hole. The contact resistance of welded bonds is three-fold, the resistance of the attaching metal, plus that of its contact with the rail, plus that of its contact with the bond terminals. The kind and character of the attaching metal is variable and there are no constants yet established for contact areas of the bond terminals and on the rail.

The resistances of stud terminal bonds are easily obtained and careful laboratory tests have been made. While these resistances are generally a little lower than for welded bonds it is recommended that they be used as a guide.

The curves Fig. 1 give the ohmic resistance of stud terminal bonds of various lengths and capacities. The resistance is given in rail feet on the same curve for convenience in converting from one to the other.

The curve is simple to read and of wide range. Start in the upper left-hand corner with the length of bond and follow across to the inter-section with the size or capacity of bond. Reading down gives the ohmic resistance. For the equivalent resistance in rail feet, continue down the vertical to the intersection with the size of rail. Reading across to right or left as indicated gives the feet of rail. To conserve space the lower curve is folded back upon itself so the figures are continued upward on the right hand side. Foot of rail equivalents are readily converted to ohms or bond size and length, also ohms to bond size and length.

The ohmic resistances of Fig. 1 are indicated for single bonding, one bond per joint including contact resistance. For multiple bonding other factors must be considered. Fig. 2 illustrates the most likely combinations to be found and the formulas show how the bonded joint resistance is obtained. The bonded joint is the space between the outside bond terminals. The splice bar contacts are independably variable and unknown so they are neglected.

The resistance of various sizes of rails at different ratios of conductivity of steel to copper are given in Table 1. These are calculated from the cross-sectional area of the rail and the specific resistance of copper. Copper steel ratio of 12:1 is reasonably accurate for track rails. The resistance of the rail in series with the bonds "d" in Fig. 2 is obtained from Table 1.

Table 2 gives the copper area equivalents for the same ratios of conductivity as Table 1.

Having figured the ohmic resistance of the multiple bonded joint from Fig. 1 and 2, the equivalent rail feet can be obtained directly from the lower part of Fig. 1.

The resistance per unit length of bonded rail, say one mile, is obtained from the formula $R = NB + T\ (5280 - NA)$.

where R = Resistance per mile of bonded rail in ohms
B = Resistance per bonded joint in ohms
N = Number of joints
T = Resistance per foot of rail in ohms
A = Rail shunted by bonds per joint in feet

Each bonded joint shunts a fixed amount of rail, leaving the balance of solid rail between joints which is obviously less than one mile. The number of joints is fixed by the individual rail length.

It will be found that considerable calculation with small decimals is required to obtain the bonded rail resistance per mile. Fig. 3 and 4 are based upon the foregoing data and for single bonded joints the bonded rail resistance per mile can be obtained without calculation. In the case of multiple bonded joints first determine the ohmic resistance per bonded joint and from the lower part of Fig. 3 the resistance of all the joints in a mile is obtained directly for standard rail lengths.

To use the curve Fig. 3 first determine the length of individual rail used, 30, 33 or 39 feet. Then take the straightened and extended length of bond in the upper left-hand corner, follow the horizontal line to the point of intersection with the size of bond, follow the vertical line at the point of intersection to its junction with the proper rail length line. Reading across at this point gives the resistance of the bonds in one mile of rail. The curve is folded back upon itself, and curves, d, e and f are continuations of curves a, b and c.

In the case of a single bond per joint, the value obtained from Fig. 3, added to that obtained from Fig. 4, gives the resistance per mile of bonded rail.

Fig. 4 gives directly the resistance of the net rail between joints per mile on the basis of the amount of rail shunted by the bonds per joint, and the individual rail length.

To use the curve Fig. 4, start in the upper left-hand corner with the inches of rail shunted by the bonds per joint. This is the distance between terminals for one bond, or the distance between the outer bond terminals in the case of multiple bonding. Follow the horizontal line to its intersection with the proper rail length line, then follow the vertical line at this point of intersection to its intersection with the size of rail. Reading across gives the resistance of the net solid rail, in one mile. For all sizes of rail other than 50 and 60-lb. read to the left. For 50 and 60-lb. rails read right. Intermediate sizes of rails can be interpolated.

Example: Find the resistance per mile of 100-lb. rail, bonded with one 13-inch 4/0 bond per joint, each bond shunting 12 inches of rail per joint, 33-ft. rail length.

From Fig. 3 we find the resistance of the bonds per mile of track equals .00945 ohms.

From Fig. 4, on the basis of 12-inch shunting per joint and 33-ft. rail, we find the resistance of the rail only equals .051 ohms.

Resistance of Bonds.....	.00945 ohms
Resistance of Rail.....	.051 ohms
Resistance per mile of bonded rail.....	.06045 ohms

In case of multiple bonding, first find the resistance of the bonded joint in ohms from Fig. 1 and 2.

For example, take case No. 5 and assume the same bond rail as given in the previous example for a single bond, that is, two 4/0 13-inch bonds with the terminals of each bond spaced 12 inches apart, 100-lb. rail, 33-ft. rail length.

Assume that letter E, Fig. 2, equals 18 inches, then d equals 6 inches. The resistance of one 4/0 13-inch bond is 58 microhms $= A$. The resistance of 6 inches of 100-lb. rail at 12 to 1 ratio, Table 1, is practically 5 microhms $= d$. From the formula of case 5 we find the bonded joint resistance equals

$$\tfrac{1}{2}(A + d) = \frac{63}{2} \text{ microhms} = 31.5 \text{ microhms.}$$

From Fig. 3 we find that 31.5 microhms bond resistance per joint equals .0052 ohm total bond resistance in one mile.

From Fig. 4 with 18 inches shunted by bonds per joint we find the net solid rail resistance to be .0502 ohms. Adding these together we have

Resistance of bonded joints.....	.0052 ohms
Resistance of rail.....	.0502 ohms
Resistance per mile of bonded rail.....	.0554 ohms

All of the foregoing data may be used for resistance measurements where the actual ohmic resistance is measured in testing, or it may be used for the purpose of calculation.

The testing of bonds in the field is very often done with commercial instruments operated on the Wheatstone Bridge principle or by equalizing the "drops" obtained simultaneously with two millivolt meters. In such cases the resistance of the joints is read in feet of solid rail and usually the propulsion current which is variable and of unknown value is utilized for the meter indications.

Fig. 5 and 6 are for use in connection with field testing. Fig. 5 shows various arrangements of bonds to be tested together with formulas which give the true resistance of the joints as tested. The reason for the spacing of the bond tester contacts, letter *X*, Fig. 5, being sometimes greater than the spacing of the bond terminals is that in many commercial testing sets the rail contact device is arranged with a spacing of three feet between contacts. The formulas of Fig. 5 are arranged for the calculation of the bonded joint resistance between tester contacts so that corrections are not required in the field.

Fig. 6 shows diagrams of commercial bond testers.

There are no alternating current instruments for measuring the resistance of rail bonds directly, so that on AC systems it is necessary to introduce a direct current for testing purposes. This may be done with a battery in a number of ways. The current introduced by the battery can be used in conjunction with an ammeter and millivolt meter for the purpose of obtaining the resistance of the bonds in ohms. It can also be used in conjunction with a bridge set where the readings are taken in terms of rail feet.

The mistake is often made to test rail bonds without previously determining the resistance to be expected. In some cases where the bonds are of high resistance with respect to the rail, the splice bars will reduce the resistance very materially and the results are apt to be misleading. For a proper interpretation of the field tests, the resistance of the joints as tested must be determined from the foregoing data.

(2) Further consideration has been given the subject of current carrying capacity of bonds but aside from preliminary tests to which reference was made in last year's report no further progress has been made on study of this subject. Representatives of the bond companies have advised that due to difficulty in arriving at any reliable figures on current carrying capacity of bonds it is doubtful if any further information of value can be obtained pertaining to this subject. It is therefore suggested that study of the subject be discontinued.

(3) The Sub-Committee has continued its study of details of bond design with a view to developing specifications and in this connection submits the following:

There are two main advantages in connection with standardization of rail bonds: 1st, manufacturing tools and stock expense; 2d, field application and stores expense.

A standard bond will permit (a) minimum number of sizes for stock, which not only reduces stores cost but may allow quicker delivery if occa-

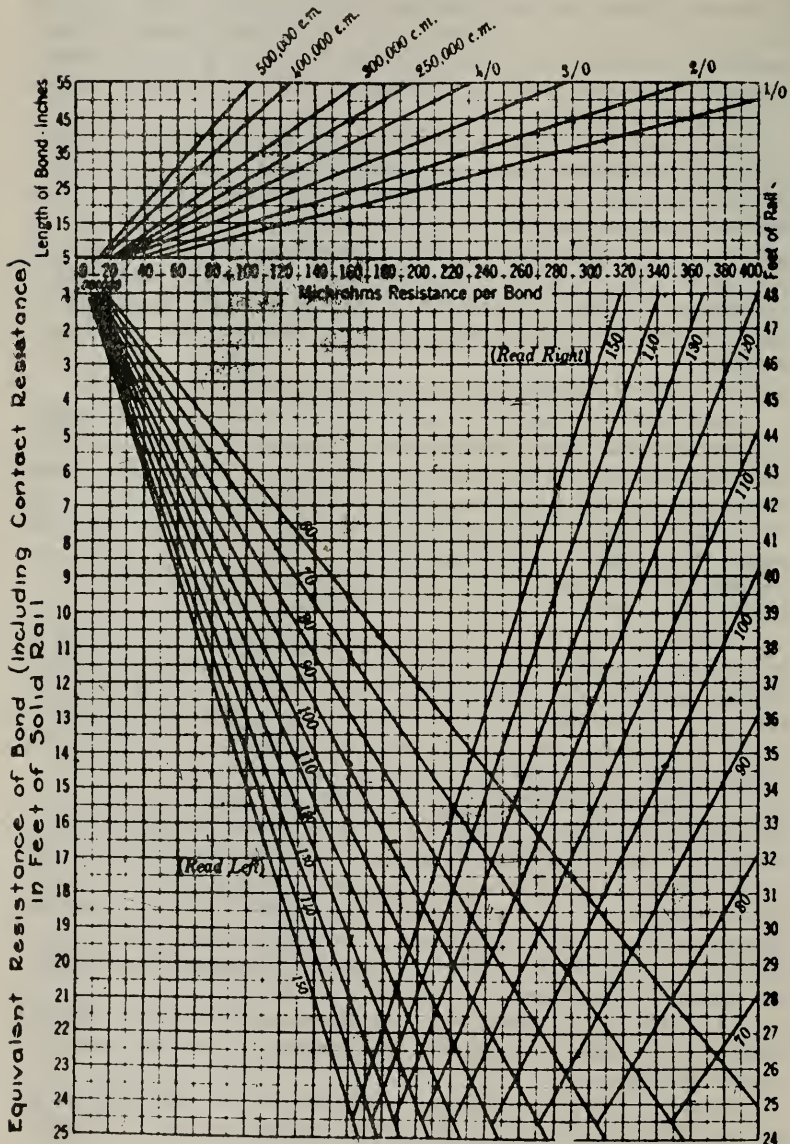
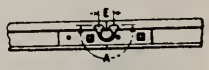

500,000 c.m.
400,000 c.m.
300,000 c.m.
250,000 c.m.
4/0
3/0
2/0
1/0
Length of Bond-Inches
Feet of Rail
Microhms Resistance per Bond
(Read Right)
(Read Left)
Equivalent Resistance of Bond (Including Contact Resistance) in Feet of Solid Rail

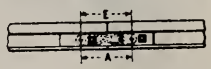
Figure 1.

Key – $A-A_1-A_2$ = Resistance of each bond in ohms, as determined by its straight and extended length.
E = Distance between outside bond terminals, or the bonded joint.
d = Resistance of rail between bond terminals in ohms.
X = Resistance of joint in ohms.

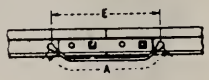
$X = A$ ohms — Case 1



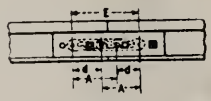
$X = A$ ohms — Case 2



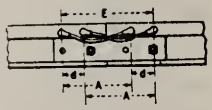
$X = A$ ohms — Case 3



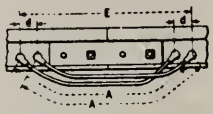
$X = \frac{A + d}{2}$ ohms — Case 4



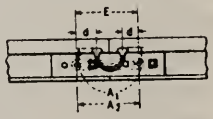
$X = \frac{A + d}{2}$ ohms — Case 5



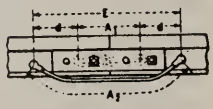
$X = \frac{A + d}{2}$ ohms — Case 6



$X = \frac{A_2(A_1+2d)}{A_2+A_1+2d}$ ohms — Case 7



$X = \frac{A_2(A_1+2d)}{A_2+A_1+2d}$ ohms — Case 8



$X = \frac{A_2(A_1+2d)}{A_2+A_1+2d}$ ohms — Case 9

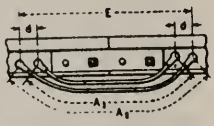


Fig. 2

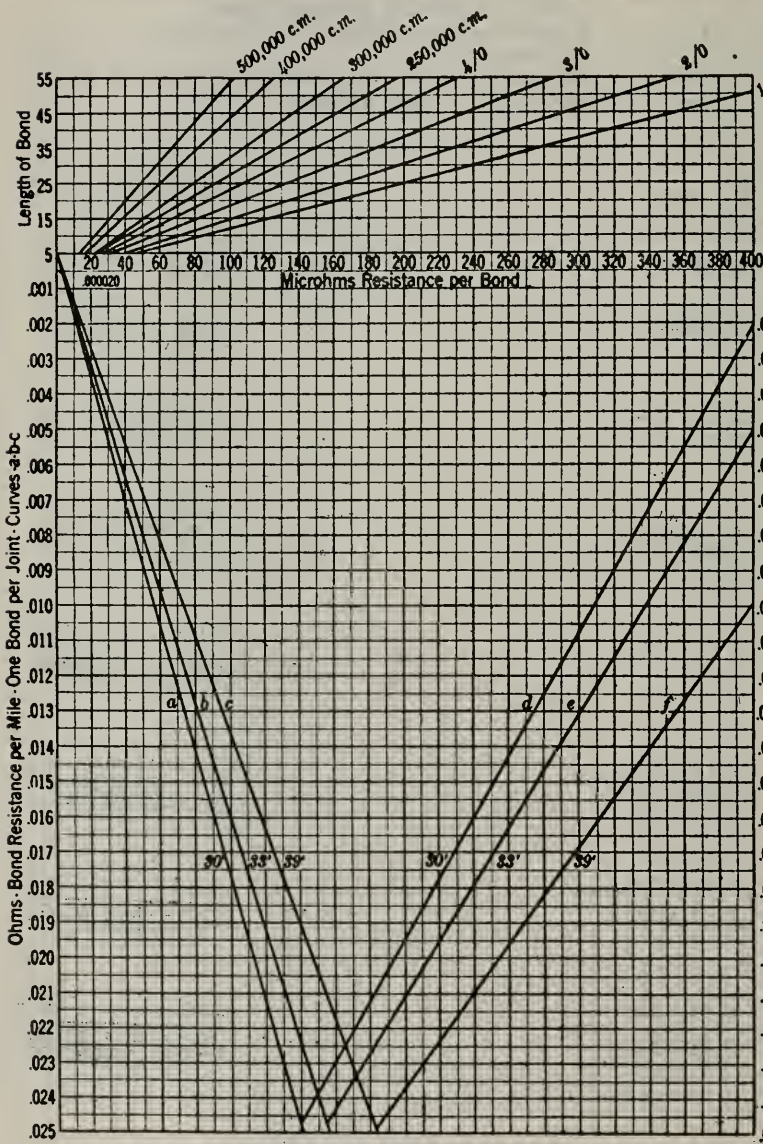

500,000 c.m.
400,000 c.m.
300,000 c.m.
250,000 c.m.
4/0
3/0
2/0
1/0
Length of Bond
55
45
35
25
15
5
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400
.000020
Microhms Resistance per Bond
Ohms-Curves-d-e-f
Ohms-Bond Resistance per Mile-One Bond per Joint-Curves-a-b-c
.001 .002 .003 .004 .005 .006 .007 .008 .009 .010 .011 .012 .013 .014 .015 .016 .017 .018 .019 .020 .021 .022 .023 .024 .025
.070 .068 .066 .064 .062 .060 .058 .056 .054 .052 .050 .048 .046 .044 .042 .040 .038 .036 .034 .032 .030 .028 .026 .024
a b c
d e f
30' 33' 39'
30' 33' 39'

Figure 3.

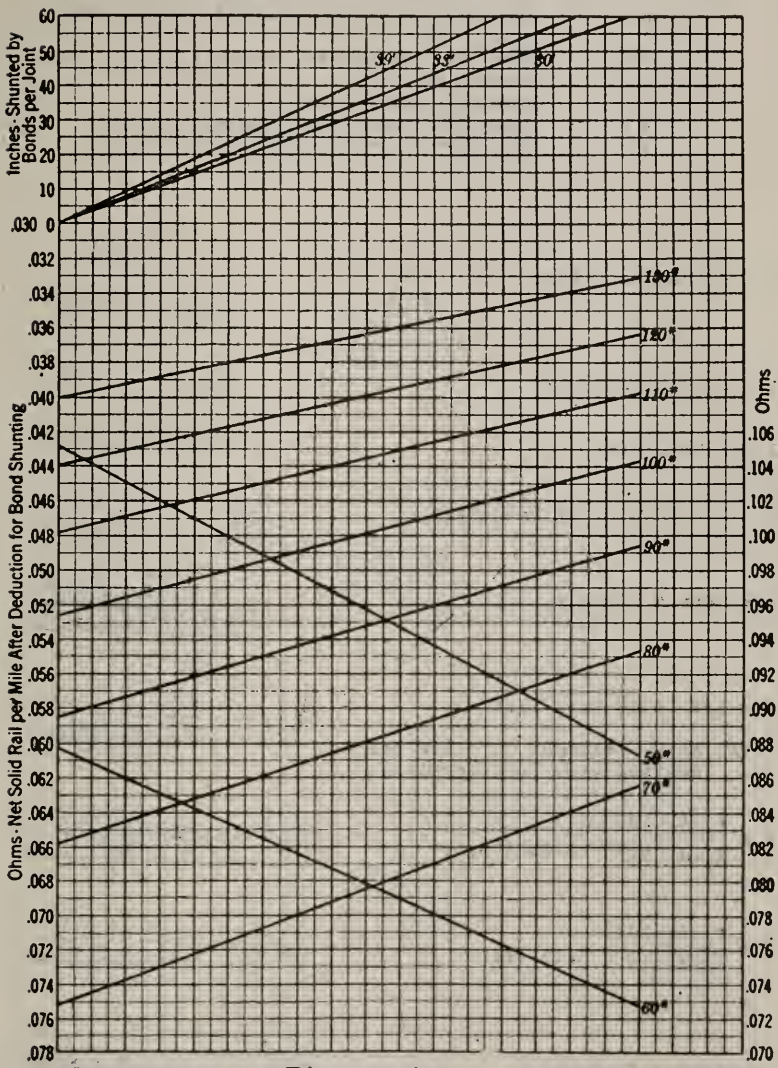

Inches - Shunted by Bonds per Joint
60
50
40
30
20
10
.030 0
39'
33'
30'
Ohms - Net Solid Rail per Mile After Deduction for Bond Shunting
.032
.034
.036
.038
.040
.042
.044
.046
.048
.050
.052
.054
.056
.058
.060
.062
.064
.066
.068
.070
.072
.074
.076
.078
130"
120"
110"
100"
90"
80"
50"
70"
60"
Ohms
.106
.104
.102
.100
.098
.096
.094
.092
.090
.088
.086
.084
.082
.080
.078
.076
.074
.072
.070

Figure 4.

Key - $A-A_1-A_2$ = Equivalent resistance of each bond in rail feet as determined by its straight and extended length.

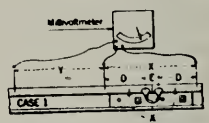
E = Distance between bond terminals, or the bonded joint.

D = Uncut rail between bond terminals and bond tester contacts in feet.

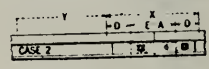
X = Spacing of tester contacts in feet.

d = Uncut rail between bond terminals in feet.

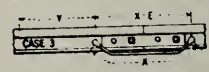
Y = Resistance of joint in rail feet as tested.



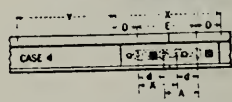
X = A + 2D Rail Feet



X = A + 2D Rail Feet

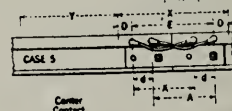


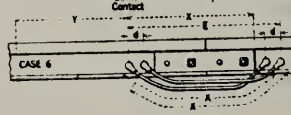
X = A Rail Feet



X = 1/2 (A+d) + 2D Rail Feet

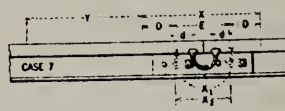
*Use Case 4 Formula



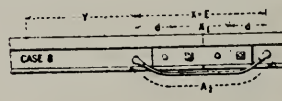


X = 1/2 (A+d) Rail Feet

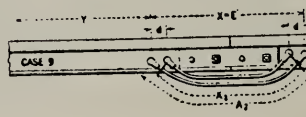
NOTE: When E exceeds X, place center contact over bond terminal.



$$X = \frac{A_2(A_1+2d)}{A_2+A_1+2d} + 2D \text{ Rail Feet.}$$



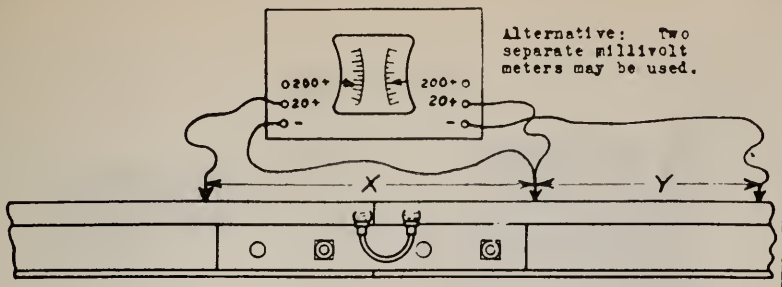
$$X = \frac{A_2(A_1+2d)}{A_2+A_1+2d} \text{ Rail Feet.}$$



*Use Case 8 Formula

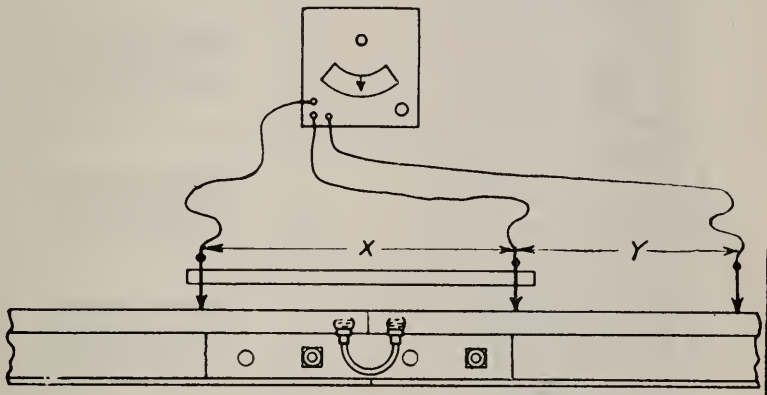
Figure 5

PORTABLE BOND TESTERS

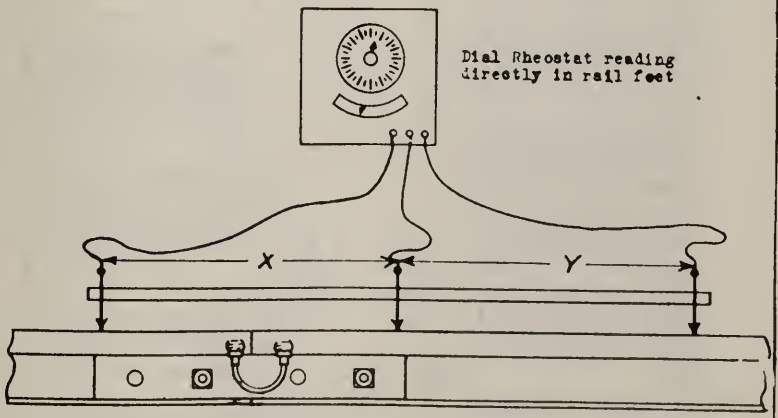


Duplex Millivoltmeter Method

"X" Normally 3'-0" "Y" Variable



"X" Normally 3'-0" "Y" Variable - Tape Measure



"X" Normally 3'-0" "Y" Normally 3'-0"

Figure 5

Weight of Rail Pounds Per Yard	Ratio of Resistance of Steel to that of Copper													
	6		7		8		10		11		12		13	
	1000 Ft.	Mile	1000 Ft.	Mile	1000 Ft.	Mile	1000 Ft.	Mile	1000 Ft.	Mile	1000 Ft.	Mile	1000 Ft.	Mile
50	.009963	.052604	.011624	.061375	.013243	.069923	.016605	.087674	.018266	.096444	.019925	.105204	.021587	.113979
60	.008303	.043839	.009686	.051145	.011071	.058455	.013838	.073065	.015221	.080367	.016606	.087680	.017989	.094982
70	.007116	.037576	.008303	.043839	.009489	.050097	.011861	.062621	.013047	.068888	.014233	.075152	.015419	.081412
80	.006227	.032879	.007265	.038359	.008303	.043834	.010378	.054796	.011466	.060276	.012454	.065757	.013480	.071174
90	.005535	.029226	.006458	.034097	.007380	.038966	.009225	.048708	.010147	.053576	.011070	.058449	.011992	.063318
100	.004981	.026303	.005812	.030687	.006642	.035070	.008302	.043835	.009133	.048222	.009963	.052604	.010794	.056992
110	.004529	.023912	.005283	.027897	.006039	.031886	.007548	.039853	.008302	.043834	.009057	.047821	.009812	.051807
120	.004151	.021919	.004843	.025573	.005535	.029224	.006919	.036532	.007611	.040186	.008303	.043839	.008994	.047488
130	.003832	.020233	.004471	.023605	.005109	.026978	.006387	.037222	.007025	.037094	.007664	.040466	.008303	.043839
140	.003558	.018788	.004151	.021919	.004744	.025050	.005930	.031313	.006523	.034445	.007116	.037576	.007710	.040707
150	.003321	.017535	.003874	.020458	.004428	.023381	.005535	.029225	.006089	.032150	.006642	.035071	.007196	.037994

TABLE 1—RESISTANCE IN INTERNATIONAL OHMS OF A CONTINUOUS STEEL RAIL AT 20° C. OR 68° F., NO JOINTS

Weight of Rail Pounds Per Yard	Actual Area in		Ratio of Resistance of Steel to that of Copper						
	Square Inches	Circular Mils	6	7	8	10	11	12	13
50	4.9	6,238,800	1,039,800	891,257	779,850	623,880	567,164	519,900	479,908
60	5.88	7,486,600	1,247,766	1,069,514	935,825	748,660	680,600	623,883	575,890
70	6.86	8,734,400	1,455,733	1,247,771	1,091,800	873,440	794,036	727,866	671,876
80	7.84	9,982,100	1,663,683	1,426,014	1,247,763	998,210	907,463	831,841	767,853
90	8.82	11,229,900	1,871,650	1,604,271	1,403,737	1,122,990	1,020,900	935,825	863,838
100	9.80	12,477,700	2,079,616	1,782,528	1,559,712	1,247,770	1,134,336	1,039,812	959,823
110	10.78	13,725,400	2,287,566	1,960,771	1,715,675	1,372,540	1,247,763	1,143,783	1,055,800
120	11.76	14,973,200	2,495,533	2,139,028	1,871,650	1,497,320	1,361,200	1,247,766	1,151,784
130	12.74	16,221,000	2,703,500	2,317,286	2,027,625	1,622,100	1,474,636	1,351,750	1,247,769
140	13.72	17,468,800	2,911,466	2,495,543	2,183,600	1,746,880	1,588,073	1,455,733	1,343,754
150	14.70	18,716,500	3,119,416	2,673,786	2,339,562	1,871,650	1,701,409	1,559,708	1,439,731

TABLE 2—AREA OF COPPER IN CIRCULAR MILS EQUIVALENT TO RAILWAY STEEL IN CONDUCTIVITY

sion requires; (b) tools that will provide for installing a maximum number of sizes with minimum equipment; (c) a uniform number of wires or strands for each size of strand or cable in the maximum number of types; (d) a uniform terminal size for each current carrying capacity in order that bonds of various manufactures may be readily interchangeable.

In pin terminal bonds the smaller the terminal the less material is removed from the rail and the less is the cost of labor and drills and the less material is required for the terminals themselves. There will be less variation in contact resistance with temperature changes as the size of the terminal is reduced.

The lay of the strand should be as short as practicable. The shorter the lay the longer is the vibration life. The chief limitation is in manufacturing. The wires should all be layed in the same direction. This is known as "loose lay."

A uniform length is desirable on account of drilling of holes in the rail where this is done at the mill, but limitations of angle bar design standardization make it somewhat difficult to standardize on bond lengths in this respect.

It is sometimes desirable to use two independent bonds per joint, of one standard size, applying one bond to a joint for low loads and two per joint where current requirements are heavier.

In the case of gas welded bonds, which are coming into use in connection with heavy electric traction, many of the limitations in the design of pin terminals do not exist and it is possibly too early to endeavor as yet to standardize that type of bond, especially as standardization is not so important as with pin terminals.

U-shaped and straight bonds each have distinct advantages under special conditions, although it is doubtful whether the U-shaped is satisfactory in capacities greater than 4/0. It is important also to so install welded bonds where they are fastened to the ball of the rail that mischievous trespassers cannot turn them over the rail where they will be destroyed by passing trains. The terminal stock may be either of steel or copper, but should be of copper if a forged design is used, unless the forging is later stamped around the strand. A copper terminal can be forged to the strand but steel may be pressed around the strand leaving the end exposed to be welded at the time the bond is applied to the rail.

It is usually advantageous to utilize a graded degree of flexibility between the bond strand and the terminal in order to damp the vibration in the strand.

It is desirable to so design the bond as to reduce the vibration to a minimum. There may be a natural period of vibration in the bond resonant with the rail vibration which will cause excessive bond deterioration by breakage and which can readily be avoided by properly choosing the length or weight of the bond.

A bronze alloy is usually used for welding. Bonds should always be made of annealed copper of 98 per cent conductivity. The following table indicates the suggested standardization:

PIN TERMINAL BONDS

					250,000	300,000	400,000	500,000
Capacity of Bond	1/0	2/0	3/0	4/0	C.M.	C.M.	C.M.	C.M.
Diameter of Terminal .	¾″	¾″	¾″	⅞″	⅞″	1 ″	1 ″	1 ″
Length of Terminal .	¾″	¾″	¾″	¾″	¾″	13/16″	13/16″	13/16″
Number of Conductors	1	1	1	1	1	1	1	1
Lay of Strand	2.82″	3.17″	3.56″	4.00″	4.34″	4.76″	5.50″	6.15″
Number of Wires in Each Conductor	37	37	37	61	61	91	91	91
Size of Each Wire	.0537″	.0603″	.0667″	.0589″	.0644″	.0577″	.0667″	.0745″
Diameter of Pin	7/16″	7/16″	7/16″	½″	½″	21/32″	21/32″	21/32″
Length of Pin	1¼″	1¼″	1¼″	1¼″	1¼″	1½″	1½″	1½″
Diameter of Hole in Pin Terminal .	11/32″	11/32″	11/32″	13/32″	13/32″	9/16″	17/32″	17/32″
Diameter of Tapered Punch ...	13/32″	13/32″	13/32″	15/32″	15/32″	⅝″	⅝″	⅝″
Oversize Punch	15/32″	15/32″	15/32″	17/32″	17/32″	11/16″	11/16″	11/16″
Oversize pin.	½″	½″	½″	9/16″	9/16″	23/32″	23/32″	23/32″

It is sometimes advantageous to use double or divided bonds, and in that event there will be variations in the above figures.

(4) The effect of heat of welded bonds on track rails has been given further consideration by the Rail Committee of the American Railway Engineering Association and at its meeting in Chicago on March 9, 1927, adopted the following resolution:

> "The application of welded bonds to the outside of the head of the rail within the limits of the joint bars for standard bonding and outside of joint bars for special work where not practicable to apply them within the joint bar limits is good practice."

This resolution of the Rail Committee was in response to an earlier resolution of the Committee on Electricity which was presented to the Rail Committee as follows:

> "The Electrical Section looks with favor upon the extended use of welded track bonds attached to the side of the head of the rail by electric or gas weld process and asks the advice of the Rail Committee if there is any objection on their part to such method of track bonding for traction purposes."

Earl Stimson, Chairman of the Rail Committee, in transmitting the Rail Committee's resolution to the Chairman of this Sub-Committee, advises that the Rail Committee's resolution applies to propulsion bonds as well

as signal bonds and applies only to gas welding. Mr. Stimson further states that the reason for limiting the application of welded bonds to the gas process is that the subject as assigned to the Rail Committee specified gas welded bonds only. He assumes that the limited use of electric welded bonds was the reason the subject as assigned to his Committee did not include that method of welding.

In response to further inquiries by the Chairman of this Sub-Committee, the Chairman of the Rail Committee advised that from such data as the Rail Committee has been able to gather it does not favor the use of gas welded bonds on rails having other than the normal manganese content.

(5) Means of attaching bonds to manganese track rails has been the subject of further study and the following report is submitted:

Manganese rails in electrified territory have not been extensively used and consequently the application of bonds to them has not received very much attention except in a few isolated locations where the methods used were largely experimental in working out a problem which presented two chief difficulties: (a) objection to the use of heat in the application of bonds, and (b) the extreme hardness of the rail made it difficult to drill holes for mechanically applied bonds.

A study has been made of the methods used and a brief summary follows:

Gas weld or electric weld process:

Tests which have been conducted show that bonds can be readily applied by either the gas weld process or the electric weld process. It is stated by some of the welding companies that the composition of manganese rail is such as to facilitate welding and the steel flows more readily than in ordinary steel rail. The Manganese Steel Rail Company, however, advise against the use of any heat applied bonds claiming that the structure of the rail is injuriously affected. This Committee has made no investigation of the effects of heat on the rail structures and therefore welded bonds are not recommended for application to manganese rails or rails having other than the normal manganese content.

Mechanically applied bonds:

Very little has been done to develop a practical method for mechanically applying bonds to manganese rails. Several methods have been tried out to some extent but there are no records available giving comparisons of the relative efficiencies. The methods used are briefly described as follows:

Holes are punched in the rail at the factory to take a copper bushing which is expanded into the rail by means of a steel ball driven through the bushing. The ball is preferred to an expanded pin as it forces the copper into the irregular surfaces of the punched hole. Pin terminals are expanded in the ¾-inch hole made in the bushing by the ball in the usual way.

One of the railroad companies arranged for $\frac{15}{16}$-inch punched holes at the factory. These holes were then cut out to 1-inch diameter by means of carborundum wheels, the holes plugged with copper terminals to protect them against corrosion. These terminals were backed out in the field and ex-

panded terminal bonds applied in the usual way. During the last few years the 1-inch bond holes have been satisfactorily drilled at the factory using a heavy drill press and special high speed drills.

The subject of field drilling of manganese rails presents difficulties which as yet have not been satisfactorily worked out. Tests which have been conducted at the factory and in the field indicates that drilling can be done with a machine that will give a heavy rigid feed and slow speed. This speed for 1-inch drills should be about 60 r.p.m.

The manufacturers advise that they doubt that the drilling of manganese rails can be developed as a commercial proposition and naturally do not feel inclined to go into the subject very far until there is an actual demand which would justify it. Consequently our study of the subject has not gone beyond demonstrating that the drilling can be done.

Conclusions

That the subject be continued with especial reference to:

1. Study of details of bond design with a view to developing specifications covering the different classes of bonds.
2. Collection of information as to methods and extent of practice in re-applying bonds.
3. Collection of data on compositions used, if any, on rail joints to replace bonds.
4. Study of contact areas and resistances for different types of bonds.
5. Compiling information concerning rail joint clearance and its effect on rail bond design.

Appendix M

(13) ILLUMINATION

E. B. Katte, Chairman, Sub-Committee; R. J. Needham, Vice-Chairman, Sub-Committee; L. S. Billau, H. A. Currie, J. V. B. Duer, F. D. Hall, C. B. Martin, J. L. Minick, A. E. Owen, J. H. Van Buskirk, Sidney Withington, A. H. Woollen.

(1) INCANDESCENT LAMP SCHEDULE

1. The Sub-Committee has reviewed and revised the Tungsten Lamp Schedule as it appeared in Bulletin 291 of November, 1926, as indicated in accompanying schedule of Incandescent Lamps. These changes, primarily, consist of increasing the voltage of cab lamps from 33 to 34, and permitting the use of 34 volt lamps for headlight service. A 60 watt, 32 or 34 volt, P-25 bulb for headlight service was added to the list. The G.18½ bulb, in the 23 and 36 watt lamps in headlight service, Street Railway Lighting Service, has been changed to the new manufacturers' standard, A.19. These changes have been made to correspond with the Incandescent Lamp Schedule recommended by the Mechanical Division of the American Railway Association.

INCANDESCENT LAMP STANDARDS—1927

General Lighting Service

Watts	Voltages	Bulb	Base
*15	110, 115, 120, 125	S-17	Med.
*25	110, 115, 120, 125	S-17	Med.
*40	110, 115, 120, 125	S-19	Med.
*50	110, 115, 120, 125	S-19	Med.
*60	110, 115, 120, 125	S-21	Med.
75	110, 115, 120, 125	PS-22	Med.
*100	110, 115, 120, 125	PS-25	Med.
150	110, 115, 120, 125	PS-25	Med.
200	110, 115, 120, 125	PS-30	Med.
300	110, 115, 120, 125	PS-35	Mog.
500	110, 115, 120, 125	PS-40	Mog.
750	110, 115, 120, 125	PS-52	Mog.
1000	110, 115, 120, 125	PS-52	Mog.

The following inside frosted lamps are now in regular production. It is expected that they will supersede the above indicated lamps (*) and their use therefore is encouraged.

Watts	Voltages	Bulb	Base
15	110, 115, 120, 125	A-17	Med.
25	110, 115, 120, 125	A-19	Med.
40	110, 115, 120, 125	A-21	Med.
50	110, 115, 120, 125	A-21	Med.
60	110, 115, 120, 125	A-21	Med.
100	110, 115, 120, 125	A-23	Med.

High Voltage Lighting Service

Watts	Voltages	Bulb	Base
*25	220, 230, 240, 250	P-19	Med.
*50	220, 230, 240, 250	P-19	Med.
*100	220, 230, 240, 250	PS-25	Med.
200	220, 230, 240, 250	PS-30	Med.
300	220, 230, 240, 250	PS-35	Mog.
500	220, 230, 240, 250	PS-40	Mog.
750	220, 230, 240, 250	PS-52	Mog.
1000	220, 230, 240, 250	PS-52	Mog.

The following inside frosted lamps are now in regular production. It is expected that they will supersede the above indicated lamps (*) and their use therefore is encouraged.

Watts	Voltages	Bulb	Base
25	220, 230, 240, 250	A-19	Med.
50	220, 230, 240, 250	A-21	Med.
100	220, 230, 240, 250	A-23	Med.

Rough Service (Mill Type)

Watts	Voltages	Bulb	Base
*50	110, 115, 120, 125	P-19	Med.
*50	220, 230, 240, 250	P-19	Med.

The following inside frosted lamps are now in regular production. It is expected that they will supersede the above indicated lamps (*) and their use therefore is encouraged.

Watts	Voltages	Bulb	Base
50	110, 115, 120, 125	A-19	Med.
50	220, 230, 240, 250	A-21	Med.

Sign Lighting Service

Watts	Voltages	Bulb	Base
10	110, 115, 120, 125	S-14	Med.
15	110, 115, 120, 125	S-14 Blue	Med.
25	110, 115, 120, 125	A-19 Clear	Med.
		Blue	Med.
50	110, 115, 120, 125	A-19 Clear	Med.
		Blue	Med.

Floodlighting Service

Watts	Voltages	Bulb	Base
500	110, 115, 120, 125	PS-40	Mog.
750	110, 115, 120, 125	PS-52	Mog.
1000	110, 115, 120, 125	PS-52	Mog.
*1000	110, 115, 120, 125	G-40	Mog.

*For use in 23-inch floodlights under special conditions.

Train Lighting Service

Watts	Voltages	Bulb	Base
*15	32, 34, or 64	PS-16	Med.
*15	32, 34, or 64	G-18½	Med.
*25	32, 34, or 64	PS-16	Med.
*25	32, 34, or 64	G-18½	Med.
*50	32, 34, or 64	PS-20	Med.
75	32, 34, or 64	PS-22	Med.
*100	32, 34, or 64	PS-25	Med.

The following inside frosted lamps are now in regular production. It is expected that they will supersede the above indicated lamps (*) and their use is, therefore, encouraged.

Watts	Voltages	Bulb	Base
15	32, 34, or 64	A-17	Med.
25	32, 34, or 64	A-19	Med.
50	32, 34, or 64	A-21	Med.
100	32, 34, or 64	A-23	Med.

Switch Indicator Service

Watts	Volts	Bulb	Base	Service
15	30	T-6	Cand. Sc.	Westinghouse Boards
15	30	T-7	Cand. Sc.	G. E. Boards
15	70	T-6	Cand. Sc.	Westinghouse Boards
15	70	T-7	Cand. Sc.	G. E. Boards
15	140	T-6	Cand. Sc.	Westinghouse Boards
15	140	T-7	Cand. Sc.	G. E. Boards

For Use with Resistance Unit

Watts	Volts	Bulb	Base	Service
0.11 amp.	18	T-4	Cand. Sc.	G. E. Boards
0.11 amp.	18	G-6	S.C. Bay Cand.	Westinghouse Boards

Street Lighting Service

Lumens	Amperes	Bulb	Base
2500	6.6	PS-35	Mog.
4000	6.6	PS-35	Mog.
6000	6.6	PS-40	Mog.

Hand Lantern Service

Amperes	Volts	Bulb	Base	No.	Use
0.15	5.00	G-4½	Min. Sc.	..	4 cell Flashlight Battery
0.60	1.25	G-4½	Min. Sc.	19	1 cell No. 6 Battery
0.80	2.40	G-5½	Min. Sc.	35	2 cell No. 6 Battery

Motor Coach Lighting Service

C.P.	Voltages	Bulb	Base	Number	Remarks
3	6-8	G-6	DC-Bay	64	Dash
6	6-8	G-8	DC-Bay	82	Tail
21	6-8	S-11	DC-Bay	1130	Interior and Hd. Lt.
21	6-8	S-11	SC-Bay	1129	Interior and Hd. Lt.
3	12-16	G-6	DC-Bay	68	Dash
6	12-16	G-8	DC-Bay	90	Tail
21	12-16	S-11	DC-Bay	1142	Interior and Hd. Lt.
21	12-16	S-11	SC-Bay	1141	Interior and Hd. Lt.

The 3 and 6 candle power lamps may be used for sign, marker and auxiliary lighting.

Locomotive Lighting Service

Watts	Voltages	Bulb	Base	Remarks
15	34	S-14	Medium	Cab
15	34	S-17	Medium	Cab
*60	32 or 34	P-25	Medium	Headlight
*100	32 or 34	P-25	Medium	Headlight
250	32 or 34	P-25	Medium	Headlight

*The 100 watt lamp in inside frosted bulb is now being furnished and may supersede both the 60 watt and the 100 watt clear bulb lamps.

The 250 watt lamp in the P-25 bulb has superseded the same lamps in the G-30 bulb.

Street Railway Lighting Service

Watts	Voltages	Bulb	Base	Remarks
23	105, 110, 115, 120, 125, 130	S-17	Medium	
36	105, 110, 115, 120, 125, 130	S-19	Medium	
56	105, 110, 115, 120, 125, 130	S-21	Medium	
94	105, 110, 115, 120, 125, 130	S-24½	Medium	
23	105, 110, 115, 120, 125, 130	A-19	Medium	Headlight
36	105, 110, 115, 120, 125, 130	A-19	Medium	Headlight
56	105, 110, 115, 120, 125, 130	P-25	Medium	Headlight
94	105, 110, 115, 120, 125, 130	P-25	Medium	Headlight

The following gage lamps, one and one-quarter (1¼) inches maximum overall length, are for use in series with headlights.

Amps.	Volts	Bulb	Base	Remarks
.214	3	T-3	Miniature	(In Series with 23 W. Hd. Lt.)
.342	3	T-3	Miniature	(In Series with 36 W. Hd. Lt.)
.519	3	T-3	Miniature	(In Series with 56 W. Hd. Lt.)
.863	3	T-3	Miniature	(In Series with 94 W. Hd. Lt.)

The lamps listed in this schedule are for use five in series on 525, 550, 575, 600, 625 or 650 volt circuits and should invariably be so ordered.

Signal Lamp Service

Amperes	Voltages	Bulb	Base	Filament
.3	3.5	S-11	S. C. Bay Cand.	C-2
.25	8.0	S-11	S. C. Bay Cand.	C-3
.25	10.0	S-11	S. C. Bay Cand.	C-3
.25	12.0	S-11	S. C. Bay Cand.	C-3
.25	13.5	S-11	S. C. Bay Cand.	C-3

Signal lamps shall conform to A.R.A. Signal Section Plan 1544.

(2) FLOODLIGHTING

The Sub-Committee, appointed a year ago to investigate the matter of flood lighting of railway yards, finds it possible to submit only a progress report this year. Certain desirable data are not yet available and the Sub-Committee has, therefore, revised the program of work developed last year.

A careful review of existing data seems to indicate that certain factors have been rather definitely determined and established through continued and general use, as follows:

(A) Illumination Intensities in Freight Yards

Illumination intensities, when flood lights or other artificial sources of light are used, should be appreciably higher than that of full moon-light, which is of the order of 0.02 foot candles. The most commonly accepted values vary from 0.08 to 0.15 foot candles, though values as low as 0.05 and as high as 0.2 foot candles have been used. The higher values are preferable initially to allow for depreciation of the lighting units from ageing of the lamps, tarnishing of the reflectors, collection of dirt on the cover glasses, etc.

(B) Illumination Values at Engine Terminals

Illumination values in the vicinity of engine houses, turntables, inspection pits, coaling stations, etc., where the work is of a more specialized nature, are much higher than those required within the body of a freight yard and vary considerably with the character and importance of the work performed. Average values cannot readily be determined. There are, however, installations as low as 0.5 and as high as 2.0 foot candles.

(C) Height of Lighting Units

Two considerations determine the height of the lighting units above the working plane. The item of cost alone requires that the units be mounted as low as possible as the cost of both wood poles and steel towers increases rapidly as lengths increase. On the other hand the reduction of glare and the reproduction of light distribution and diffusion approaching daylight conditions require the units to be mounted as high as practicable. The generally accepted compromise between these two extremes is a minimum of approximately 70 feet with such additional heights as cost considerations will permit.

(D) Glare Reduction

It must be remembered that with a mounting height of only 70 ft. the lighting units will be within the normal angle of vision of an engineman in the cab of a locomotive to within a distance of about 200 ft. from the base of the tower on which the unit is mounted. Glare will be pronounced under this condition. Glare is measured by the intensity of the light emanating from the reflecting surface of the lighting unit and is usually expressed in terms of candlepower per square inch of reflecting surface. Commercial types of flood lights vary from a minimum of about 500 candlepower per square inch to a maximum of 3000 candlepower per square inch, depending upon the size of reflector, lamp, etc. These values are many hundred times greater than the normal capacity of the human eye and must be reduced for obvious reasons. The methods commonly employed to reduce glare to a minimum are to so locate the lighting units, both vertically and horizontally, that they will not normally be within the range of vision of the enginemen, or yardmen, or to apply lightly frosted or amber colored cover glasses to the lighting units. The use of light amber colored cover glasses is highly desirable, as light colored in this manner appears to penetrate fog more readily than white or clear light.

(E) Location of Lighting Units

The selection of locations for floodlighting towers calls for consideration of three features. Towers should be so located that the floodlights will not interfere with main line signals and operations, they should be so located that expansion of the yard will not require the removal of the tower foundations, which are both large and heavy, and they should be so located if possible that the direct rays of light will strike the sides of

the cars in the yard at a slight angle to improve the diffusion of the light in the passage ways between tracks.

(F) Tower Design

Most of the steel towers of commercial design are of tapered form, small at the top and large at the base. Such towers require relatively large foundations and must be designed to suit local conditions.

The Sub-Committee is of the opinion that a tower design may be developed which will permit a somewhat greater choice of selection and now have this subject under advisement. The Sub-Committee is also endeavoring to collect data concerning the various methods employed in laying out installations in the expectation that a standard method acceptable to all interested parties may be developed.

Conclusions

1. That the schedule of incandescent lamps presented herewith be accepted as recommended practice and the subject continued. It is not recommended that the list be now printed in the Manual, on account of probable changes in the near future.
2. That the study of floodlighting be continued.

Appendix N

(14) DESIGN OF INDOOR AND OUTDOOR SUBSTATIONS

J. V. B. Duer, Chairman, Sub-Committee; W. M. Vandersluis, Vice-Chairman, Sub-Committee; B. F. Bardo, L. S. Billau, C. L. Doub, J. C. Davidson, C. P. Ferguson, J. S. Hagan, C. B. Martin, S. Withington, P. S. Mock, H. Pattison, H. W. Pinkerton, J. S. Sharpley, J. J. Skelly, L. S. Wells, R. P. Winton, G. I. Wright.

The program of work for this Sub-Committee was outlined as follows:

1. Determine conditions affecting selection of indoor and outdoor types of station.

2. Determine applicability of various methods of controlling substation and equipment as follows:

a. Manual control
b. Remote control
c. Supervisory control
d. Semi-automatic control
e. Automatic control

3. Study and report on present development and major considerations in selection of:

a. Circuit breakers—normal and high speed A.C. and D.C.
b. Air break switches.
c. Transformers—self-protecting, air-cooled, oil-cooled, oil-insulated water-cooled.
d. Synchronous converters, motor generators, synchronous condensers, static condensers, mercury rectifiers.
e. Protective devices:
   1. Relays.
   2. Lightning arresters.
f. Meters and meter transformers.

4. Design best fitted to obtain a maximum of safety and continuity of service during maintenance and repairs, and operation.

5. Miscellaneous important questions:

a. Tabulation of minimum clearances between conductors, and conductors to ground for various voltages, both indoor and outdoor.
b. Tabulation of adequate insulation, phase to phase and phase to ground, for various voltages, both indoor and outdoor.
c. Study of permanent and emergency grounding practices.
d. Study of possibilities in unit type of construction as applied to substations.

Action Taken

(1) The Sub-Committee feels that, among the conditions which have a bearing on the selection of the indoor or outdoor type of substation, there are two major conditions to be given consideration; first, the location of the substation with respect to surrounding property, as well as the character

of the property; second, the character of apparatus which the substation is to accommodate.

When rotating apparatus is installed in a substation it is of course necessary to provide housing for such facilities as cannot be exposed to the weather. This applies also to certain other types of apparatus such as mercury arc rectifiers, which are not at present built for outdoor service. A general outline of the subject was given in the report of the Committee last year.

It may be said in general that the decision to select indoor or outdoor equipment for a static substation is one of economy. It is true that in some instances, such as location in a residential neighborhood where appearances are important, or in crowded districts where space is limited, the adoption of an indoor type may be justified even at additional cost, both of installation and subsequent maintenance. It is true to some extent also that the higher the voltage handled the greater the advantage of outdoor apparatus.

Apparatus designed for use out of doors (especially circuit breakers) is in many instances more expensive than indoor apparatus. On the other hand, the indoor type of substation requires a more or less elaborate building, which in itself is an expensive item, together with cells for circuit breakers, etc., and also involves costly conduit and cable installation. A small building may be required in any event for the use of the operator if the substation is attended, and to house a storage battery, relays, meters, etc., even if the substation is to be controlled from a remote point or is automatic.

Other things being equal, there is no doubt that the use of outdoor apparatus—transformers, circuit breakers, etc.—spread out so there is plenty of room to work around them, is likely to be more satisfactory than an indoor installation. Any trouble which occurs is not as likely to spread throughout the station as is the case indoors, and any fire which may occur is easier to fight. It is also in general easier to clear up trouble and to safely start at least partial operation after a failure.

(2) The first thing to consider in the selection of a control arrangement for the substation apparatus is the proper source of power for actuating the operating mechanisms. There are three methods which are in general use; namely, storage battery, alternating current supplied from the substation bus and alternating current supplied independent of the substation circuits.

The most common method is perhaps by means of a storage battery which is usually charged either by a small motor generator set, or by a static rectifier. When a rectifier is used it may be of the so-called "trickle charger" type. When a reliable independent source of alternating current power is available, the local operation may be controlled by such a supply. Unless absolutely necessary the alternating current supply for the local control should never be taken from the substation circuits, since, at times of power failure, the ability to control the apparatus is a very important matter.

The methods of closing the different apparatus installed in the substation may be by means of solenoids or magnets, or by motors. The solenoid has

a more rapid action and requires little maintenance. The motor operation is slower but where large circuit breakers are involved much less current is required than for solenoid operation.

The tripping is usually performed by small solenoids, actuated either by controllers from a remote point or through contactors operated by series transformers connected in the main circuits to automatically open the circuit, when it is subjected to short circuit or overload.

It is always desirable for the apparatus to be controlled from a remote point in order to operate a large number of switches in a short time. If the substation is non-automatic and requires the attendance of an operator the control can be accomplished satisfactorily by controllers mounted on a switchboard in the station and directly connected to the apparatus to be operated. This method requires at least one conductor for each operation of the particular apparatus involved. This method can also be used for control from some point, distant from the substation, in which case a multiple conductor cable must be used between the substation and the control point. The number of conductors in the cable depends upon the number of operations desired. In order that the size of conductors may be as small as possible in the cable, the apparatus is operated by contactors nearby and these are controlled from the remote point. As each operation is on a different circuit, simultaneous operation and indication of the different switches or circuit breakers can be obtained.

A method of remote control has now become common, which enables the apparatus in the substation to be controlled from very remote points, over a small number of conductors. This method is known as "Supervisory control," of which there are three general systems; namely, selector, distributor and carrier current.

The selector system employs selector relays similar in general principle to those developed for train dispatching service. Manipulation of a selector key automatically sets up a circuit and performs the operation desired. Three conductors are usually required between the operating station and the substation. A maximum of about 100 units can be controlled over one set of line wires, but as simultaneous operation or indication is not obtainable where there are a large number of devices to be operated, the speed of operation is slowed up. Approximately 8½ seconds are required for each operation, or a total of 17 seconds for a complete cycle of operation and indication.

The distributor system is somewhat similar to the old multiplex telegraph system. Two synchronously rotating distributors operate, one at the substation and one at the control point. Arms of these distributors continuously sweep over corresponding contact segments at each point, completing any one of about 50 operating circuits during each revolution. This system permits control and indication of 50 switches or circuit breakers over a set of line wires and selectors between stations in a period of less than five seconds after operating the master key. Indications of all changed conditions are reported in the dispatcher's office within five seconds after

the operation is completed in the outlying station. The position of each device is automatically checked every five seconds. These circuits may be employed for the operations and indications desired. Usually four conductors are required between the operating point and the substation.

The third system employs selectors with carrier current circuits, but your Committee has no detailed information on the practical operation of this system at the present time.

Of the systems outlined above for supervisory control, the first is utilized as a rule where a relatively small number of operations is contemplated—usually six or eight—as with a large number of devices and resulting number of circuits, the first cost becomes very high. The second system is advantageously employed where a number of stations can be served by the same group of line wires, such as may be located along a railroad. Any number of operations up to a maximum of 192 can be handled on one group of line wires, but this system is limited to locations where a great many operations are not to be performed and the speed of operation is not an important consideration. The third system permits 100 operations over each set of wires, and provides rapid operation, and is advantageously employed for the largest installations. All three schemes usually require storage batteries.

It sometimes occurs that a substation is required to operate entirely automatically. In this instance the load or voltage conditions automatically start a sequence of operations which ends by cutting the substation in on the line or shutting it down where it is no longer required. This may be applied to rotary substations or static substations equally well, and has the advantage that no operator of any kind and no control connection is required at any outlying point. Sometimes it is desirable to make a substation semi-automatic, in which case an operator receives indications as to the status of the load or other characteristics, even to the extent of being informed when the door is opened for admitting a maintainer or other person. In some instances, the station is operated fully automatic, but in the event of an emergency or disturbance, or to anticipate load conditions, a remotely located operator may assume control.

The Sub-Committee submits this report as a report of progress and recommends that its work be continued for the following year, especially with respect to further development of the control systems.

3 (a) DIRECT CURRENT CIRCUIT BREAKERS

The two types of circuit breakers now used in direct current railway circuits are the carbon circuit breaker, which has been used for many years, and the high-speed circuit breaker. This latter type is a development of the last few years. Both types are air breakers.

Carbon Circuit Breakers

This type of breaker is designed with copper leaf brush main contact and auxiliary carbon arcing contact. The requirements of a good carbon circuit

breaker may be briefly summarized as: good contact, low operating temperature of current carrying parts, self-cleaning contacts and rugged mechanical construction to withstand the heavy forces which are imposed when the breaker opens under load. A carbon circuit breaker will open in from .08 to .15 seconds as compared to the opening rate of high speed breakers which is from .004 to .008 seconds.

Carbon circuit breakers may be of the hand-operated or electrically-operated type. In railway substations the breakers may be designed to trip on overload, on reverse current or designed to remain closed on overload and to open only on short circuit.

As applied to railway substations the carbon breakers may be arranged to close either manually or electrically, by remote control or, as in the case of automatically reclosing feeder breakers, through the action of suitable relays.

High-Speed Breaker

The high-speed breaker is considerably more complicated than the carbon circuit breaker. It is electrically operated and full automatic in its operation. The breaker is closed electrically and is held in the closed position by a holding coil. The breakers may be arranged to open either on short circuit or on heavy overload. Ordinarily when applied to feeder breakers the overload setting is high, and the breaker is tripped by short circuits as differentiated from overloads.

The high-speed breaker is tripped through the action of a series coil. On short circuit the current through this coil causes a change in flux in the magnetic circuit which holds the small holding armature. The design is such that tripping action is almost instantaneous on short circuit and the breaker contacts begin to open in about .004 second.

Application of Circuit Breakers

Carbon circuit breakers are used on all direct current voltages in railway service. High-speed breakers have been applied on both normal 600 volt third rail and trolley, and on high voltage overhead trolley systems.

Until the last few years, carbon circuit breakers were used almost exclusively in both machine circuits and feeder circuits of direct current substations. This is the least expensive arrangement but provides less protection to substation machinery and connected trolley circuits than high-speed breakers do. When short circuits occur on D.C. feeder of high current carrying capacity and low resistance, the tendency for commutators of D.C. generators and the D.C. end of synchronous convertor to flashover is acute. This is particularly so on 60 cycle synchronous convertors. With 25 cycle converters the effect of short circuit is less severe.

The principal advantage of the high speed circuit breaker is the protection which it affords the commutating machines in the substation. Since the high-speed breaker opens the circuit in less time than it takes for a given commutator bar to move between the positive and negative brush arms, on the D.C. end of synchronous converter or D.C. generator, flashovers of

commutators due to disturbances on the direct current circuits are practically eliminated. Another advantage of opening the circuit quickly is the reduction of burning of overhead trolley under the pantograph and reduction in damage to motive power equipment when short circuit occurs on cars or locomotives.

High-speed breakers have been applied to feeder circuits with carbon circuit breakers in machine circuits, to machine circuits arranged to cut in current limiting resistors when short circuit occurs, and to both feeder circuits and machine circuits.

High-speed circuit breakers in either feeder or machine circuits effectively protect the substation equipment from direct current short circuits, external to the station. If high-speed breakers are used in feeder circuits, the only additional protection gained by using high-speed breakers in machine circuits is the protection against direct current short circuits on the D.C. bus in the station. This occurs so infrequently and the additional protection afforded by the high-speed breaker in such a contingency is so small that it would appear that the general use of high-speed breakers in both machine and feeder circuits is not justified.

When there are a large number of feeders from a substation in comparison with the number of machines in that station, high-speed breakers have been applied in machine circuits and carbon circuit breakers in feeder circuits in order to reduce the first cost and still secure complete protection of the substation machinery. With this arrangement, the high-speed circuit breaker is so connected in the machine circuit that when it opens on the short circuits, the current limiting resistor is inserted in this circuit. When an external short circuit on a feeder occurs, the high-speed breaker in the machine circuit opens to limit the D.C. short circuit current to value which the machine can carry momentarily. At the same time, but acting more slowly, the carbon feeder breaker in the feeder circuit on which the short has occurred, will open, clearing the short circuit. After the feeder breaker has opened, the high-speed breaker automatically recloses, short-circuiting the series resistor in the machine circuit and the station is again normal, except that the feeder breaker is now open on the defective circuit. During the time the high-speed breaker is open, which is in the order of one second, the substation D.C. bus voltage is lowered which is noticeable only by a flickering of lights on the trains.

There is considerable variation in opinion between engineers as to the relative advantages of high-speed breakers in machine and feeder circuits and this still may be considered an open question.

Automatic Reclosing Breakers

When carbon breakers or high-speed breakers are applied to substation feeder circuits or to tie circuit breakers between the trolleys in tie stations, they may be of the automatic reclosing type. There are two forms of control which may be used on the automatic reclosing breakers.

In the first type of control the re-set or closing coil of the tie breaker is connected to the feeder side of that breaker. When the breaker is open

it will not reclose until voltage is applied at third rail or trolley, from an external source. In the event of short circuit, the breaker after opening cannot reclose against the short circuit. This is due to the voltage not being available on the closing coil as long as the short circuit is maintained. This form of control is applicable only where there are two or more points of feed to each section of third rail or trolley. Even then, when all points of feed on a section are open, additional means must be provided for re-energizing that section. This in fact means that this type of automatic reclosing is suitable only for circuits having a feed from two opposite points.

A second form of automatic reclosing breaker which has been used in both automatic substations and tie circuit breaker stations is of the so-called resistance measuring relay type. A comparatively high resistance is connected across the circuit breaker contacts so that when the breaker is open, as for instance on a short circuit, a limited current will flow through this resistor to the short circuit. Relays are connected to this resistor on the Wheatstone bridge principle in such a way that they hold the circuit breaker open as long as the resistance from the substation bus to the point of short circuit is below a pre-determined value. When the resistance from the substation to the point of short circuit is above the pre-determined value or when the short circuit is completely cleared, the reclosing relays permit the circuit breaker to close. This form of control is effective but has the possible operating disadvantage that approximately 10 amperes are fed into a short circuit from each feeder breaker connected to the section on which the short occurs. When the feeder breakers are open, this may at times be advantageous in burning off minor short circuits.

On third rail installations when automatic reclosing breakers are used in tie stations, it has been considered advisable in some instances to provide remote or supervisory control for opening and locking out tie circuit breakers, even though the tie breakers are automatic in opening and closing. It is obvious that this is advantageous in emergencies to deenergize any third rail section even though there may be no short circuit on that section, and still keep other trolley or third rail sections alive.

Alternating Current Circuit Breakers

The circuit breakers for rupturing alternating currents may be of an airbreak type or an oil-insulated type, in which the arc which is produced across the contacts when the breaker is opened, is ruptured in the oil. The first type has not been used to any great extent for the rupturing of high currents on any but the very low voltage circuits. This type has lately been given consideration for as high as 15,000 volts, but no extensive information is available now and will, therefore, be made a subject for investigation and report during the coming year.

Oil Circuit Breakers—General Considerations

A.C. oil circuit breakers have two limitations; continuous current carrying capacity and rupturing capacity. The continuous current carrying

capacity depends on the size of the contacts and the heat dissipation in the oil. The rupturing capacity is limited by explosion pressures in the tank and burning of the contacts. Oil circuit breakers should be selected to be able to rupture the maximum energy that can be fed by the system through the breaker on short circuit. In determining the maximum short circuit current, due consideration should be given to possible future additions to the capacity of the system and parallel feeds into the short circuit. The breakers should be able to rupture the short circuit current several times in succession without injuring the breaker so that the breaker can be kept in service without examining the contacts.

Tanks for oil circuit breakers should be of substantial construction and means provided for conveniently lowering the tanks for maintenance. Frames for the breakers should be of structural steel and all castings made of steel. High tension bushings should have adequate flash-over values for the line voltage.

Breakers should be installed with sufficient clearance so that they can be maintained with safety without interruption to adjoining apparatus and high enough above the floor to prevent accidental contact with the high tension bushings.

All breakers should be arranged to "trip free" so that the operator cannot hold the breaker in on short circuit. The "anti-pumping" feature should be incorporated so that the breaker cannot close after tripping on short circuit.

On account of the heavy arc, which is produced across the contacts of an A.C. oil circuit breaker, some arrangement must be made in the circuit breaker to keep this arc from its main contacts. This arrangement is known as the arcing contacts. If there are no arcing contacts, or if they are not properly designed and located, excessive burning of the main contacts will result, and after a few openings, even under normal load conditions, the contacts are so rough that imperfect contact is made.

There are practically no circuit breakers on the market today which do not have some arcing contact arrangement which will carry the arc while the circuit is being interrupted. The design of this arcing arrangement depends upon the speed with which the arc is to be broken, the resultant voltage tending to maintain the arc across the opening contacts and affects the interrupting ability of the circuit breaker.

Methods of breaking the arc are almost as numerous as there are manufacturers of circuits breakers, all of which are along the following principles or a combination of them:

(1) Opening the arcing contacts at the same rate as the main contacts open.
(2) Opening the arcing contacts at a higher rate than the main contacts.
(3) Using the explosive action of the gases produced by the developed arc, to help extinguish the arc.
(4) Use of magnetic blowout coils.
(5) Use of arc chutes.

All of the above methods, if properly applied, will prevent excessive burning of contacts. The first method is only adaptable to circuit breakers of medium voltage and interrupting capacity. If used for other than this interrupting capacity, either the speed of contact opening must be increased, the breaker must be of a more rugged design to withstand the increased gas pressure, or a combination of both.

The second method can be used with good results on the breakers of large interrupting capacity, or breakers of the higher voltages. A degree of ruggedness to breaker parts can be omitted if the third method mentioned is combined to a certain extent with this arrangement.

The third method covers approximately the same class of circuit breakers as the second arrangement, but is probably superior as to the speed of breaking the arc and control of the gas formation. Another advantage is that the gas pressures are taken care of in the explosion chamber and, therefore, the tanks can be reduced in strength. It has the disadvantage of numerous parts to inspect and maintain, and complicated passages and separators for the escape of the developed gases.

The fourth arrangement, combined with the fifth, has lately come into use in oil circuit breakers, due to the demand for a breaker of very high interruptive ability combined with a higher speed of circuit interruption than heretofore demanded. Its arrangement is a magnetic field produced about an arc chute, as has been used for a number of years on contactor switches. Its application and the power requirements demanding its use have been discussed elsewhere in this report.

A heavy arc produces magnetic effects which tend to quickly lengthen it to the rupturing point without the aid of blowout coils. This magnetic effect increases rapidly with the increase in short circuit current which the breaker is called upon to open and makes possible the rupturing of excessive currents in a very short time with arcing contacts of a simple nature. On the breakers where the current is below a value where this magnetic blowout effect takes place, which condition predominates to a great extent in the higher voltage breakers, arcing contacts must be so designed as to open at a high rate, in order to rupture the arc. This magnetic blowout effect begins to become effective at about 8000 amperes.

Oil Circuit Breakers—33,000 Volts A.C. and Higher

Since transmission line voltages of 33,000 and above have been found to be more economical for power systems distributing over an extensive territory, the connected substations will involve high tension circuits which will require switching apparatus insulated for these higher voltages in order to properly sectionalize and protect those circuits.

If the system involves the feeding of single substations with two or more high tension lines, both the step-up and step-down transformers can be considered as a part of the line and the operating can be done on the low tension side and high side circuit breakers can be excluded. This arrangement has the advantage of a reduction of the magnitude of the voltage

surges resulting from high tension switching. Sectionalizing of the high tension lines is then carried out by the use of airbreak switches, either manually or electrically operated.

If the system involved is a network of lines connecting widely separated loads, the connected substations must be equipped with high voltage oil circuit breakers in order to insure adequate protection of the service.

It is highly desirable to eliminate the oil circuit breaker in cases where the higher connected voltages are involved, not only because of a high first cost, but also on account of the costly maintenance required. But this elimination has been found undesirable on a large number of systems and therefore the high voltage circuit breakers must be considered.

An advantage to be found in the use of high voltage circuit breakers, is that the short circuit currents are not as large as for the low voltages. Therefore, the circuit breakers do not have to withstand the heavy current duty involved in the low tension circuits. As the voltage increases the current interrupting ability requirements decrease until the most important consideration for high voltage circuit breakers becomes the insulation and clearance factors. Since the interrupting ability of a circuit breaker depends largely on the size, shape and construction details of the tank and the bracing of the terminals the cost of the low voltage breakers will vary with this factor, while the insulation and clearance requirements become the determining factors as to cost for circuit breakers of the higher voltages.

Since the high voltage circuit breaker tanks are necessarily large, due to the clearance requirements, an added advantage is found in the large body of oil involved, which gives more than the adequate space necessary for dissipating the energy of the short circuit arcs, but requires the handling of very large volumes of oil in maintenance work.

A disadvantage to be found in the necessity of large porcelain insulators is that the necessary clearances prohibit extensive bracing of the terminals inside the tanks. The two terminals per phase, along with the moveable contact constitute a loop which tends to expand, due to the force of the magnetic flux, when a current flows through a breaker. This force due to the magnetic flux along with the internal disturbances caused by the arc upon opening, may be great enough to crack the porcelain bushings and cause an insulation failure with probable arc to ground inside the tank. This arc may produce sufficient expansion of the gases above the oil to completely disrupt the breaker. The possible explosion of a circuit breaker containing a large quantity of oil forms another disadvantage of the high voltage circuit breaker, in that the burning oil is difficult to quench.

Another consideration in the use of high voltage circuit breakers is the necessity of extensive filtering apparatus for cleaning the oil and likewise greater labor costs. Oil tanks having a storage capacity equal to that of the breaker tank are necessary in order that the oil can be removed from the breaker for maintenance purposes. Therefore, when the higher voltage circuit breakers are installed the oil system becomes a considerable item of expense.

High Speed Oil Circuit Breaker

The use of high speed circuit breakers for alternating current circuits has not been general in this country because the need for development has not this far been very great. There are several advantages in quickly rupturing short circuit currents, the most important to the operator is undoubtedly the reduction of damage to the line or apparatus in the event of trouble. The quick rupturing of a circuit in trouble also reduces system voltage surges which may on occasion be troublesome. If a transmission line can be cleared promptly in the event of disturbance the process of clearing can often be completed before the short circuit current reaches its maximum value. This obviously reduces stress on generators as well as line. Another advantage of a quick rupture is the reduction of energy transfer to neighboring communication circuits by electro-magnetic induction. The interference from such causes is a function of the actual transfer of energy, and, with a short time element, a considerably higher voltage value can be reached without undue difficulty than is the case if the disturbance extends over a period of several cycles.

It is thus sometimes desirable to clear short circuits within a period of half a cycle, and various types of circuit breakers have been proposed with this end in view. The type which is most fully developed is an oil switch of more or less standard design, except that it is heavier in its moving parts than the usual type of circuit breaker of similar capacity. This breaker is closed against a very heavy spring and upon the occasion of a short circuit, a light relay closes contacts, allowing the flow of a heavy direct current through the trip coil, releasing the spring and opening the breaker. Direct current is employed for tripping, in order to avoid delay in building up magnetism in the trip coil, which is "supersaturated." Such circuit breakers have ruptured up to 30,000 amperes at 11,000 volts, 25 cycles in about half a cycle. The contacts are so designed that there is a virtual magnetic blowout of the arc.

It is a characteristic of oil circuit breakers that the arc is not quenched until the current value passes through zero—thus if the short circuit occurs close to the end of a wave, the arc may not be broken at the next succeeding zero point, the rupture being delayed until the second zero point following the short circuit. In this instance the time required is obviously slightly more than half a cycle.

Air type circuit breakers for the lower voltages have been developed successfully capable of opening large amounts of alternating current in a few hundredths of a second. Such breakers are of the same general arrangements as direct current breakers.

Two considerations are important in designing circuit breakers—one is the normal current-carrying capacity and the other is the rupturing capacity. The current-carrying capacity of oil circuit breakers is to some extent a function of the size of the contacts and the amount of oil in the tank, and thus its capacity for dissipating heat, while the rupturing capacity is a function of the pressure the tank can withstand and to some extent the

speed of opening, which determines the duration of the arc. In some designs the main circuit is carried outside the tanks, and the circuit breaking contacts thus do not carry the current except for a short period during the process of opening. The oil tanks are thus relatively small.

The duty imposed by normal flow of current is obviously a function of the load on the system fed by the circuit breaker, while the rupturing requirement is a function of the capacity of power plant or substation behind the system. Both considerations should be carefully kept in mind in selecting circuit breakers for any given location.

Truck Type Oil Circuit Breakers

Truck type oil circuit breakers have many advantages for medium capacities up to 15,000 volts for indoor mounting. They provide ease and safety for maintenance as the whole truck is dead when it is removed from the bus structure. The interruption to service in case of trouble is reduced, as a defective switch can be replaced with a whole new truck and complicated switching arrangements are not required for spare breakers. There is considerable saving in space required for truck type breakers and still provide adequate room for safe maintenance. The principle of the indoor truck type breaker could be applied to outdoor breakers by mounting the breakers on wheels and providing couplers similar to those used on multiple unit cars for the control circuits.

3 (b) DISCONNECTING SWITCHES

The use of Air Break Disconnecting Switches can be divided into two classes:

(1) Disconnecting switches in series with oil circuit breakers which are not required to break any current.

(2) Horn Gap Switches for breaking load current.

Disconnecting switches are usually of knife blade type without horns and may be mounted in any position. These switches require only one break but may be mounted on rotating insulator and have two breaks. The principal requirements of these switches are ample current carrying capacity, self-cleaning contacts and protection against contacts freezing where sleet is found. These switches may be hook stick operated or remote control by means of levers insulated from the blade by porcelain insulators.

Horn gap switches should be used to break load current or where there is danger of the switches accidently opening under load. Horn gap switches can usually be used for much less cost than oil circuit breakers up to 132,000 volts for opening parallel transmission circuits or charging current on transformers. The safe rupturing capacity of horn gap switches depends on the spacing between phases and wind conditions. Where it is necessary to open switches under loads of 200 or 300 amperes, it will usually be more satisfactory to use oil circuit breakers. Horn gap switches should have ample spacing between the phases and the insulators should have sufficient flashover value to prevent arcing to ground. Greater flashover value for insulators on horn gap switches is usually required than for

line insulators for the same voltage. Horn gap switches should preferably be installed on the top of the structure where sufficient room can be provided for the rise of the arc. Single break switches will operate as satisfactorily as double break switches, with the added advantage of simplicity and lower cost. Horn gap switches may be of the horizontal or vertical break type, but the horns should break at the tip as the arc cannot be depended upon to rise on the horns of its own accord. The main contact should be self-cleaning and protected against freezing. Flexible shunts should be provided around current carrying parts. All bolts should be of non-corrosive material.

Horn gap switches may be mechanically operated from the ground or motor operated. For light loads automatic load tripping can be provided.

3 (c) POWER TRANSFORMERS

On account of the wide differences in the characteristics of power systems, the proper selection of a transformer to give satisfactory operation becomes a very important matter. The particular characteristics of the transformer, when they approach the limits of design, involve an increase in expenditure for the unit. Therefore, for economy, the selection should be made on the basis of the least deviation from the most economical design as may be required for efficient operation.

There are two main requirements which have been found desirable for transformers and which are the determining factors, as to the cost, when deviations from standard design are necessary. These requirements are protection against heavy short circuits and reactance values.

Since the capacities of power transformers have, of necessity, increased considerably within the past decade, there has been a corresponding increase in the stresses to which windings and cores are subjected when short circuits and grounds occur on the connected system. Where large systems are interlinked, resulting in momentary short circuits at sustained primary voltages, the internal stresses are so excessive that the ordinary type of transformer, used heretofore, may become inoperative on account of displaced windings and damaged insulation.

For this reason it has become necessary to build transformers with the windings so strongly braced as to withstand the maximum short circuit stresses across the secondary terminals, with sustained voltage on the primary terminals. Transformers so constructed are considered protected types. All large transformers, which are built today should have incorporated in their design the bracing necessary for the protection as required by the system to which they are to be connected.

On any system the quantity of reactance plays a very important part in its satisfactory operation. Since the per cent reactance of a transformer is mainly determined by the degree of coupling of the windings, the lower this requirement becomes, the more difficult it is found to give a high degree of protection against stresses due to short circuits. Certain types of windings are adopted to ease of bracing for short circuit protection and

others are adapted to the ease with which a close coupling of windings can be made. Unless extreme limits of protection or coupling are desired, any type of winding can be designed to give a reasonable degree of both.

Other fundamental requirements to be met in power transformer design are: (1) adequate insulations; (2) heat dissipation and (3) mechanical strength. Other factors pertinent to the choice of type of cars and winding which are not fundamental but which are most important are weight and cost and relative ease of assembly and repair. A transformer of a given rating and specified electrical characteristics may be one of several types with respect to core and winding.

For convenience, the various types of cores used in power transformers may be classified as follows:

(A) Central vertical leg and winding with four vertical legs external to winding. This is variously termed by manufacturers as "Distributed Core" or "Distributed Shell" type. The central leg on which are the windings may be either rectangular or cruciform in section.

(B) Core with three vertical legs, the windings being on the central leg with coils on horizontal plane. This is usually called a core type, although windings are surrounded by iron.

(C) Core with two vertical legs, the windings being on both legs. This is a simple core type.

(D) Core with three vertical legs, the windings being on all three legs. This is 3 phase core type.

(E) Shell Type. Windings are usually of the rectangular pancake type mounted vertically with core laminations stacked horizontally, surrounding the coils.

The windings of core type transformers may be either the concentric type, in which the high tension and low tension winding are arranged concentrically; or the interleaved group type in which form wound circular disc high tension and low tension coils are stacked in groups.

In small single phase power transformers up to about 100 K.V.A. capacity and voltages up to 6600 volts, the Type "A" distributed shell (also called distributed core) with concentric or interleaved windings is an economical design which has been generally adopted by leading manufacturers. In transformers of this class the fundamental requirements of adequate insulation, heat dissipation, and adequate mechanical strength are not difficult to meet, and the problem is one of economical design from standpoint of weight and first cost to meet specified electrical characteristics.

In the larger capacities at all voltages, and in the voltage range between 6600 and 110,000 volts in all capacities there is a wide divergence of opinion between designing engineers as to the relative advantages of the shell and core types of constructions.

Insulation

The problem of insulation of individual turns of a coil, the insulation between adjacent coils, and between groups of coils and ground is not difficult in either the shell or core type, and this need not be considered as a

major factor in the selection between the two types, except for voltages higher than 110,000.

Heat Dissipation—Core Type

The proponents of the core type transformer believe that type of construction is superior to the shell type from the standpoint of heat dissipation. The windings of the core type usually are of the interleave circular disc type in the larger sizes, with discs horizontal arranged in a stack. The coil discs are separated by strips of insulating material usually placed radially between coils. Both edges of all rectangular wire in the discs are in contact with the cooling oil, except the wire covered by the radial strips of insulating material between coils. Heat generated in the parts of the windings under the insulating spacers is conducted a minimum distance along the wires in both directions to the parts of winding between insulating spacers. It is claimed that liability of hop spots is reduced because the length of wire along which heat must be conducted to reach cooling oil is less with this type of construction than that of the shell type described below. It will be noted that in this type of core transformer the hot oil must flow horizontally to the inner and outer edge of each coil of the stack, before rising in the tank, in the space between core and windings, and between windings and tank.

The advocates of the shell type of construction take the opposite view that heat is dissipated more readily in shell type transformers than in core type transformers. In the shell type transformer the rectangular pancake coils are supported with planes of coils vertical. Adjacent coils are usually separated by vertical serpentine spacers along the sides of the coils, and straight vertical spacers at top and bottom of coils. The pancake coils being vertical, it is claimed that oil circulation is less impeded than in the core type with horizontal coils. Also, it is claimed that the cooling of the core is more effective, since the laminations surround the coil and edges of laminations are exposed to the cooling oil. The core type is often designed with oil ducts through the core to secure better cooling.

Mechanical Strength

Where transformers are to be connected to power systems of large generating and transmission capacity, the requirements of adequate mechanical strength to withstand the heavy forces resulting from short circuits are most important.

Engineers favoring shell type transformers believe that the concentric winding, used on certain core type transformers, is not best adapted to applications of this type because of the great radial forces which occur between the low tension winding and concentric high tension winding on short circuit. The tendency is to expand the outer coils, and to crush the inner coils. The interleaved core type and the shell type are similarly constructed with reference to the relation of coils. High tension and low tension windings are arranged in pairs, and the forces between coils tending to throw them apart are counterbalanced except at the ends of the stack. In either type effecting bracing on the end coils can be applied.

The advocates of the core type transformers believe that the circular disc type of coil used in core transformers has certain mechanical advantages over that of the rectangular pancake coil used in shell type transformers. It is claimed that the circular coil is easier to manufacture without danger of weakening the dielectric strength of the insulation of individual conductors. When current is passed through an individual coil of any shape, there is a tendency for it to assume a circular shape, and for this reason manufacturers of core type transformers claim that there is less chance of distortion of the circular coils. The advocates of shell type transformers using rectangular coils points out that when high and low tension coils are interleaved, the forces reacting between the pair of coils are practically balanced with respect to attraction and repulsion of the two sides of the coils, and the tendency to assume a circular form disappears in a practical design of shell type transformer.

In core type circular coil transformers, the coil stack is much longer than in the shell type. If in manufacture, coils are not stacked accurately with centers in line, there are unbalanced forces. The advocates of shell type transformers are of the opinion that it is more difficult to construct a core type transformer than a shell type transformer with these unbalanced forces minimized. The opposite view is taken by manufacturers of core type transformers.

There is the same divergence of opinion with regard to ease of repairs. When it is necessary to replace a coil in the shell type transformer, all of the laminations must be removed from transformer and after the coil is replaced the transformer laminations restacked. In the core type transformer the yoke iron at the upper end of the core may be more easily removed to give access to coils.

The coils of the shell type and of the interleaved core type transformer are easily accessible after the iron is removed. The coils of the concentric type of transformer are more difficult of access after the iron is removed. After windings are repaired, the laminations must be built up on shell type transformer which requires more time than replacing the yoke of iron on the core type. There is a difference of opinion relative to the ease of blocking and bracing transformers after iron is assembled.

Air blast transformers of all sizes and voltages are of the shell type for the reason that this type lends itself more readily to air cooling.

Another consideration in connection with the selection of transformers is the method of keeping the transformer windings cool. There are five methods in general use at the present time, namely, oil-insulated, self-cooled; air blast; forced oil circulation; natural connection; oil-insulated, water-cooled.

All large power transformers are oil-insulated and the cooling method is either self or water-cooled. The self-cooled transformer takes up much more space than the water-cooled transformer, due to the surface necessary for the dissipation of heat. This large surface is secured by the use of radiators which are placed about the tank and the cooling is done by circulation through them. Numerous tubes extending from top to bottom of the

transformer, outside the tank and connected to it, are also used on self-cooled transformers. On smaller size transformers, the tank is simply corrugated. This method is only suitable for outdoor service.

The water-cooling is done by the circulation of water through coils immersed in the oil near the top oil level. This method allows of smaller space than the oil-cooled transformer, but cannot be used in outdoor sub-stations, in localities where the temperature reaches a point low enough to cause freezing of the water and probable bursting of the coils. Also, extensive piping may have to be done to bring the cooling water to the substation and continuous supply must be arranged for, even to the extent of duplicate supply lines.

Air blast transformers are usually used in connection with rotating equipment. Where forced ventilation fans are used for cooling converters, motor generators, frequency changers, etc., it is economical to utilize this air blast also for cooling the windings of transformers which may be connected. This type of cooling is used only on indoor transformer installations. Conditions of space, cost and elimination of oil usually control the selection of this type of cooling.

Forced oil and natural air circulation are not very generally used for power transformers, but are mentioned here as methods of cooling, which may be used in case they are found more economical or desirable for special installations than the above methods.

Auto-Transformers—An auto-transformer is one in which there is only one winding and an iron core. The difference in voltage between the primary and secondary circuits is secured by making taps to the winding at the desired point.

There are very few classes of service where auto-transformers are used that could not be taken care of by two-coil transformers, but where low ratios are involved the auto-transformer is the more efficient.

The auto-transformer has been used in certain cases at ratios higher than 3 to 1, but its greatest field is for this ratio and lower. At a ratio of 3 to 1 the amount of copper required is equal to that necessary for the two circuit transformers. Below this ratio the amount of copper required is less. Therefore, at or below the 3 to 1 ratio the copper losses are equal or less than the two-coil transformer with a corresponding higher efficiency.

The impedance drop in the secondary winding of the auto-transformer has a negative effect which tends to raise the secondary voltage instead of lowering it. This gives the transformer a high regulation and adapts it for use as a voltage regulator, provided that it is so designed as to allow a variable displacement of the proper portions of the windings with respect to each other.

Under short circuit conditions on the secondary side of the transformer, the value of current flowing through the short is very large, probably four times that allowed to flow by the use of a two-circuit transformer of equal rating.

3 (d) ROTATING MACHINERY

Synchronous Converters—In the selection of rotary converters for railway service, one of the first characteristics that must be studied is that of rotative speed. A high speed converter is lighter, cheaper, and occupies somewhat less floor space than a low speed machine, but in general has a shorter life and costs more to maintain. To successfully handle railway loads without an excess of installed capacity the commutators of the converters should be liberally designed, with a low voltage between commutator bars and a maximum distance between brush arms. For a given frequency the distance between brush arms is proportional to the peripheral speed of the commutator, so that a high peripheral speed is necessary.

For a given peripheral speed, the centrifugal force acting on the commutator segments tending to spring them out of position varies inversely with the diameter of the converter, so that a commutator of large diameter on a low speed machine can be more easily manufactured than one of small diameter on a high speed machine.

The same reasoning applies to the insulation on the armature winding, that of a low speed machine being subjected to less mechanical stress than that on a high speed machine, which tends to reduce failures due to insulation breakdowns.

The flywheel effect of a low speed large diameter machine is greater than that of a high speed machine, and the low speed machine therefore takes more energy in starting and requires more time to come to rest after power is shut off, but is not as liable to shunt due to surges.

The low speed machine is preferable for large traction systems where the conductivity of the distribution network is high due to many tracks being connected in parallel, where frequently heavy load peaks are encountered, and short circuits necessarily are severe; whereas on small systems the high speed machine may be preferable due to its lower first cost.

The necessity for commutating poles is not as great for synchronous converters as for generators of equal rating due to the smaller effective armature current and lower self induction of the armature winding of the converter. Low speed, low voltage converters, which are not subjected to severe overloads, may be successfully operated without commutating poles. Modern design, however, favors the use of commutating poles for most applications, as the material in the machine can then be worked at higher densities, reducing the weight and cost of the equipment per K. W. of rating.

The interpole has the disadvantage that when the converter is started from the A.C. side as an induction motor, severe sparking will occur at the D.C. brushes, and machines with interpoles must be provided with means for raising all the brushes from the commutator, with the exception of two small pilot brushes which are used for the operation of relays and voltmeters.

Synchronous converters are usually started in one of the three ways outlined below:

1. **As an Induction Motor by Supplying Low Voltage to the A. C. End of the Machine.**

This is the simplest method of starting as it eliminates synchronizing but draws a large amount of current at low power factor, which is a disadvantage if the rating of the converter is large in proportion to the generating and distributing system which feeds it, but in large systems is not a consideration. When the machine synchronizes it may have reversed polarity on the D. C. end, and this is corrected by slipping a pole which can be done by momentarily reversing the field connections until the correct polarity is obtained, or by separately exciting the field from the station control battery, a separate motor generator set, or the D. C. bus of the station, or by disconnecting from the A. C. supply and reconnecting again until the correct polarity is obtained.

The low voltage may be obtained by taps on the secondary of the main supply transformer, by the use of an auto-transformer supplying reduced voltage to the primary of the main transformer or by changing the primary connections of the transformer to wye for starting and to delta for running. The use of secondary taps has been the usual practice, but changing the primary connections is now becoming quite common, as it eliminates the use of switches of large current capacity in the secondary circuit of the transformer, and is readily adaptable to automatic switching, although it involves additional high voltage circuit breakers.

2. **By Means of a Separate Direct Connected Induction Motor Having at Least One Pair of Poles Less Than the Converter and Capable of Accelerating the Converter Above Synchronous Speed.**

The starting motor should be specially designed for high starting torque with a minimum KVA input so that the advantages of this method of starting may be fully realized. Starting in this manner requires a small KVA input and is therefore desirable in cases where starting the rotary from the A. C. and would cause an objectionable drop in voltage on the transmission system, which might affect other synchronous apparatus. It has the disadvantage that the converter must be synchronized and that the additional motor increases the shaft length of the machine, as well as an additional cost for the induction motor.

3. **As a Direct Current Motor.**

The rotaries are started by means of a starting rheostat in the same manner as any direct current motor and the rotary synchronized and thrown on the line. The power required to start is low and the system disturbances at a minimum.

The disadvantage of this system is that upon a complete shutdown there is no D. C. current available for starting. Also there is the expense of a large rheostat to consider. It is, therefore, necessary to equip at least one of the machines for A. C. starting under such conditions.

On large systems where the surge due to starting machines A. C. is not noticeable, the expense and complications of D. C. starting may be avoided.

Relative Advantages of Synchronous Converters, Motor Generator Sets and Mercury Arc Rectifiers

In deciding upon the type of equipment for railway service the principal factors to be considered are first cost, operating cost, adaptability to service

requirements, and reliability of operation. In general, it is difficult to classify various types of equipment with regard to first cost, as variations in service conditions materially affect these costs. For 750 volts and lower, a rotary converter installation, including building, is in most cases cheaper than either a mercury arc rectifier or a motor generator set. For 1500 volts there is no material difference in first cost, while for 3000 volts the mercury arc rectifier is much cheaper than either of the other two equipments.

In considering the relative advantages of rotary converters versus motor generator sets, the obvious differences between the two are that a rotary installation has a rather definite ratio between the A. C. voltage supply and the D. C. voltage output, and is not readily adaptable to A. C. power factor correction, whereas in the case of the motor generator set, the direct current voltage may be varied in any desired manner, and any desired amount of power factor correction may be obtained. In most railway installations, constant D. C. bus voltage with an average A. C. power factor of unity is satisfactory and the rotary converter is capable of meeting these requirements unless the variation in high tension voltage is excessive, which, however, would be a special and rather unusual case.

The mercury arc rectifier presents the attractiveness of having no main moving parts, which would seem to eliminate most of the troubles encountered with rotating machinery, but the susceptibility of rectifiers to internal short circuits presents a source of trouble equivalent to the commutation difficulties of rotating machinery. Arc rectifiers also cannot be used on mountain roads to convert regenerated D. C. power to A. C. for return to the high tension transmission system.

The regulation of a mercury arm rectifier is similar to that of a rotary converter, the direct current voltage bearing a constant ratio to that of the A. C. supply. The power factor of the rectifier is more constant than that of a converter under varying loads, and is substantially unity, except at very light loads, where the exciting current of the transformers reduces the power factor. Experience has shown that for operating voltages of 750 volts and lower the rotary converter is most satisfactory in a majority of cases.

For 1500 volt service, the rotary converter loses some of its advantages over the motor generator set, because for maximum reliability, both use two 750 volt machines in series, but the motor generator set consists of one motor and two generators on the same shaft, although at a sacrifice of reliability, either type can be built to deliver 1500 volts with one commutator. At this voltage the mercury arc rectifier begins to compete economically with rotating apparatus, and as it has a higher efficiency than such equipment, it will probably be favored in the future as soon as sufficient operating experience has been gained from units now in service.

For 3000 volt operation, the motor generator has been favored, since the design of rotary converters to operate in series at this voltage is difficult. It is here that the mercury arc rectifier has the greatest possibilities, as it has a decided advantage in first cost over all other types of equipment, and

the design difficulties of the rectifier do not increase materially with the voltage.

Frequency Changers—Where two alternating current power systems are inter-connected at the same frequency and operate synchronously, the connection is static; that is, either through transformers or direct connection. Where, however, the two systems are of different frequencies, or where it is not practicable to operate them synchronously, or where a close control of the load through the connection is desirable, independent of conditions of voltage, frequency, or power factor, rotating apparatus is used.

If the problem is purely one of change of frequency, the connecting motor-generator may be composed of two synchronous machines on the same shaft coupled together, each independently excited by its own exciter. The exciters are usually also mounted on the main shaft, as is the starting motor, if one is used. In order to facilitate synchronizing and load control, the stator of one of the machines is often so arranged that it can be rotated about the shaft as desired, to modify phase relationship between the two machines.

In this "double synchronous" type of frequency changer a short circuit on one system may not draw much power from the other, as the current feeding a short circuit is often highly reactive or "wattless" and the phase relations of the two systems do not change automatically. This may have some advantages, but under some circumstances, such as the supply to a given load from both systems, may cause undesirable complications. To meet this difficulty frequency changer machines are sometimes built with one main unit in the form of a wound rotor induction motor, the other machine being a synchronous machine. The induction motor stator is then excited from the first system and the rotor from the second system through a transformer with tap changing facilities and usually at relatively low voltage. The number of poles and the speed characteristics of the combined unit are such that the field rotation of the induction motor is added to the mechanical rotation to produce 60 cycles in the stator, from the 25 cycle excitation. Through the field excitation transformer taps, the field or rotor can be over-excited in such a manner that the 25 cycle circuits compensate for low 60 cycle power factor. Direct current over-excitation of the synchronous machine may be employed to improve the power factor of the 25-cycle system in the usual manner. The characteristics of a tie of this kind are much the same as those of a static transformer connection in that voltage disturbances of one system are transmitted to the other. This reduces complication in the case of parallel operation from the two systems for a given load.

In the event of a tie between two systems by means of what might be called a "constant frequency" or rigid motor-generator connection, there is a definite minimum size of machine which it is practicable to operate to hold the two systems together in synchronism and take care of the inevitable slight changes in frequency which are always present. This minimum size has been found to be approximately 10 per cent to 13 per

cent of the aggregate connected capacity of the smaller system in the case of steam plants, and 20 per cent to 25 per cent in the case of hydro plants. If the amount of power to be transferred is less than the minimum rating as thus determined, there is obviously poor economy, and the installation may not justify the investment. There are also instances where interconnection is desirable, but where frequency variation of one or both systems is so great as to prohibit the use of "constant frequency" sets. Furthermore, the power transferred through sets of this kind is dependent on various conditions in one system or the other, and may not be under direct control. It is often desirable to control directly the power passing through the set irrespective of all other conditions in either system, and also to automatically hold it at a definite predetermined value so that, for instance, a small system will not supply more than its fair proportion of a given load, or conversely that a large system shall supply an amount of power to a small one at all times as desired.

To meet these requirements, so-called "variable speed" motor-generator sets have been developed as connections between systems of different nominal frequency, and indeed also of the same nominal frequency but of widely varying capacities. One method of arriving at the solution of this problem is, of course, the use of a synchronous converter in series with an "inverted" synchronous converter, but this arrangement is not common. The usual method of accomplishing this result is by the use of a main set consisting of a wound rotor induction motor and synchronous generator as in the scheme mentioned above, but with the difference that by means of additional auxiliary regulating apparatus the field of the induction motor is made to rotate electrically at varying speeds. This rotation allows speed control and therefore load control. Below synchronous speed the voltage of the regulating set opposes the secondary circuit in the rotor of the main induction motor, and above synchronous speed the regulating motor voltage imposes added voltage on the rotor or secondary circuit; that is, below synchronism, current induced in the secondary or rotor of the main motor, which would be lost in resistance, under usual methods of speed control, is transferred through the regulating set back into the line, and above synchronism power is furnished through the regulating set from the line to the main rotor.

One method used to accomplish this consists of a number of auxiliary apparatus, including essentially (1) regulating machine which is an A. C. commutation machine with slip rings, the rotor being quite similar in general design to a synchronous converter; (2) A. C. exciting machine which is similar to a three-phase wound rotor induction motor, the rotor being used as the armature; and (3) D. C. exciter which furnishes excitation to the two synchronous machines of the A. C. exciting set. There are also facilities for driving these machines at proper speeds.

The control of load is performed by a reversing rheostat which controls the excitation of the field of the A. C. exciting machine from a maximum in one direction to a maximum in the other.

Another method used for controlling the slip frequency and therefore the speed of the induction motor, and consequently the load transferred through the set, is by means of a single regulating motor of the commutation type having shunt fields excited at slip frequency. Three phase voltage, at low frequency from this motor, is applied to the slip rings of the main induction motor. The regulation in this instance is performed by what is known as an "ohmic drop exciter" similar to the armature of a rotary converter with slip rings and commutator, but without field winding. Power is supplied to this exciter through the slip rings from the main line, while power for excitation of the regulating machine is taken from the commutator and through three sets of brushes set 120 electrical degrees apart.

With the set running at exactly synchronous speed, the field of the ohmic drop exciter is stationary in space and direct current is taken from its commutator. The regulating motor thus supplies direct current to the main motor secondary or "field." At other than synchronous speed the magnetic field revolves at the slip speed, and the voltage on the commutator of the regulating motor is of the same frequency as the secondary voltage of the main motor. The voltage of the excitation of the field, and thus the speed and therefore the load of the main induction motor, is varied by means of a brush shifting device on the ohmic drop exciter, which moves the brushes to include more or fewer commutation bars between brushes for each phase, thus varying the slip frequency voltage.

The characteristics of the variable speed frequency changer sets are such that power may be transferred in either direction at any desired amount, so that mutual stand-by service may be supplied between two power systems so connected. For example, an electrified railroad running over a long distance through territory served by several power companies may purchase power economically in predetermined amounts from various power companies, each supplying power independently of all conditions either on the railroad's own lines or on the systems of the other power companies.

Motor-generators of various types may be made to function as synchronous condensers to improve power factor on power circuits thus connected when they are not required for transferring power. This may be accomplished for both systems simultaneously by separating the two main units mechanically at the coupling. This is sometimes done by means of a clutch, for ease of manipulation. Where improvement of power factor in one circuit only is desired, the set while operating as a condenser is merely disconnected electrically from the other power system and operated as an idle motor with over-excited field. Even when transmitting power, the machine may be employed to improve power factor up to the extent of its capacity, by manipulation of the field of the synchronous unit. Spare equipment not required for transfer of power may thus be more fully utilized.

Phase Converters—It is sometimes desirable to supply a single phase load for railroad operation directly from a three phase source of the same frequency, wherein it may be important for commercial reasons to maintain a balance of load on the three phases. A small unbalance of load of this

kind is usually not important, but where the railroad load forms a relatively large proportion of the total load, it is necessary to make special provisions, especially in the field of the generating unit. The unbalance also, if it is very great, causes a lack of balance of voltage among the phases, which may be undesirable, and also to some extent reduces the effective load capacity of the generators.

In order to eliminate difficulties of this kind there has been developed a phase converter or phase balancer by means of which the single phase load is balanced among the three phases of the generating plant. There are various types of machines of this nature, and normally they may be operated, so to speak, in either direction; that is, to balance a three phase source supplying a single phase load, or to supply three phase power from a single phase source. This latter application is utilized in the case of heavy constant speed locomotives employing three phase induction motors taking power from a single phase trolley.

One type of phase converter is in the form of a two-phase induction motor. Such an induction motor, after being started, will continue to operate on one phase, and the disconnected phase may be used as a source of single phase power, displaced about 90 degrees from voltage and current of the supply phase. After such a machine has been started as an induction motor, one of the phases is reversed and connected to the supply in series with the load. The action is entirely automatic and no regulators are required.

Another type of phase balancer consists of a large and a small unit mounted on the same shaft. The large unit has the same capacity as the unbalanced load and is similar to a synchronous motor with a heavy squirrel cage attached to the rotor to reduce impedance. The stator of the smaller unit is wound poly-phase and the rotor contains two separate windings displaced 90 degrees apart. This rotor is wound for the same number of poles as the larger machine. The currents transmitted are resolved into synchronous and inverse. The synchronous components have the same phase rotation as the three phase generated power and drive the machine. The balancing action occurs on account of the fact that the inverse components have an opposite phase rotation. Such a machine automatically balances any single phase load, provided the net unbalancing is within its capacity.

Synchronous Condensers—When the field magnets of a synchronous motor are over-excited, a quadrature leading current is caused to flow. This characteristic of the synchronous motor makes it valuable for use as a power factor regulator, and when so used it is called a synchronous condenser.

On systems which involve a large amount of inductive load with corresponding demand for lagging wattless exciting current from the supply system, the synchronous condenser has proved satisfactory for eliminating this wattless current from the system without reducing the amount taken by each individual piece of apparatus, or affecting their operation in any way. The field excitation of the synchronous condensers can be so adjusted that they demand an amount of loading wattless current taken by the inductive apparatus, so that the current actually supplied by the system contains

no wattless component, and hence is directly in time phase with the impressed voltage. The extent to which this power factor correction can be regulated depends entirely upon the balance between the wattless K.V.A. of the installed inductive apparatus and the K.V.A. of the synchronous condensers with the proper degree of over-excitation.

An inductive load in actuality is a load which requires excitation current, which is lagging. A synchronous machine is simply a mechanism by which excitation energy and current may be introduced into the system. If this synchronous machine be placed at the load center of the system, the excitation current may be introduced at this point, and if introduced only in the proportion required by the load, there results that no excitation current has to flow over the transmission from the generating station, only load current, which is unity power factor current.

To introduce at the load center more excitation current than is required by the load is to waste energy, unless it is desired to use this energy in raising the system voltage at this point by an amount proportional to the negative drop of leading compensating current over an inductive line between the load center point and the generating point.

A synchronous machine designed to introduce excitation energy into a system requires a very large field structure and should have a relatively large reactance to stabilize its operation (large air gap).

A synchronous machine designed to take electrical energy from a system and convert it to mechanical energy needs a field structure only large enough to supply its own excitation energy, and not one large enough to supply its own plus the excitation energy of a large number of other machines. As a motor it requires a relatively low reactance (small air gap).

It is evident that the two designs are different fundamentally.

It is true that either is most economical when carried to the limit of the design possibilities.

In small installations where switching becomes a relatively large factor, a compromise design may prove economical. In larger installations this is not true.

Very often a compromise is purely a compromise per se. It is dictated by factors other than the pure economics of the situation, and is accepted as a compromise for which one is willing to pay a price in order to meet the other conditions involved. Careful analysis will translate the advantages of compromise design from economy to some of these other conditions, except possibly for small installations as above mentioned.

The Sub-Committee submits this report as information and recommends that the work be continued during the following year along the lines of revision of the information at hand and a detailed study of protective devices and apparatus not covered in this report.

4. Study and report on substation design best fitted to obtain a maximum of safety and continuity of service during maintenance, repairs and operation. This was covered in report for 1926, pp. 137-139, Bulletin 291, November, 1926.

5. (a) Compile tabulation of minimum clearances between conductors, and conductors to ground for various voltages, indoor and outdoor.

(b) Compile tabulation of adequate insulation phase to phase and phase to ground, for various voltages, indoor and outdoor.

(c) Study and report on permanent and emergency grounding practices.

(d) Study and report on possibilities of unit type of construction as applied to substations.

Parts "a" and "b" involve a questionnaire which is just taking shape and which it is hoped will be a part of 1928 report.

Parts "c" and "d" have been considered this year, and the following paragraphs are submitted as a preliminary report.

(C) Grounding

Grounding in or at a substation is a protective measure and is done to keep the wire or equipment "grounded" at the same potential as the medium from which work on the "grounded" wire or equipment is to be done. It means that the "grounded" wire or equipment is electrically connected to earth, or to adjacent steel work, or possibly to return circuit by means of a high capacity, low resistant wire. All substation construction should include facilities for grounding any high potential wire or equipment in the substation. Grounding protects the workman from induced or directly applied voltages on the wire or equipment on which he is working and due to any cause whatsoever.

Grounding arrangements or facilities may be either of a permanent or emergency nature. Permanent grounding devices are those which are installed at one location in the station circuit only. This arrangement usually consists of a disconnecting switch with the jaw side permanently connected to the circuit to be grounded and the hinge side permanently connected to ground. This switch can be arranged to be operated locally or from a remote point. Permanent grounding devices are usually required where frequent grounding is necessary, in locations that are high above the ground and therefore difficult or dangerous for the application of grounding devices, and on circuits which have such great clearances from structures, on account of high voltage, as to be beyond reach. In such cases remote controlled mechanism or operating rods and bell cranks for the operation of the grounding switches must be used on account of their inaccessibility.

Some substations may be so arranged that one of the buses can be grounded, using fixed apparatus, and by means of this bus any of the major equipment in the substation can also be grounded.

Emergency grounding devices may be either portable or fixed. The portable kind consists of an insulating wood pole, whose length is dependent upon the normal voltage and location of wires to be grounded. To one end of this pole a substantial conducting clamp is fastened, the design being such that by rotating the pole about its long axis, the clamp is tightened on the wire. Permanently soldered to the clamp is a variable length of flexible copper strand usually insulated for 600 volts and terminating in another substatial conducting clamp of the "C" type for fastening to ground wire, rod, steel work, etc. The length of strand depends on location of parts to be grounded, and in size it should be large enough to

carry any instantaneous short circuit current without fusing. The fixed emergency ground is similar to the portable one except that the clamp, on the end of the strand opposite the pole, is omitted and is replaced by permanent connection to ground wire, bus or rod.

The emergency grounding device is used by affixing the "C" clamp at end of strand to "ground," then applying clamp on pole to wire or equipment to be grounded. This operation must be done from a safe place, because the wire to be grounded may be found energized. It is usual to set up rigid rules to govern the method of grounding, those qualified to do it, and the method of procuring and tagging circuits or equipment to ground.

In order to prevent the possibility of grounding a circuit which has not been de-energized and therefore forestall the possibility of damage to the conductor or injury to the workmen, many operators require the testing of the circuit before grounding. There are a number of voltage detectors on the market. Some make use of the electrostatic field about the conductor and some are simply high resistances with a lamp in series. In substations where circuits are placed in such a manner that an arc, in rising, would come in contact with a circuit above, the policy of testing circuits before grounding is good practice. This is equally true when clearances make it necessary to get too close to the circuit in order to apply the grounding device. In all cases of grounding, the grounds should be applied at points on both sides of the apparatus or circuit on which work is to be done, unless the circuit can be energized from one end only.

(D) Unit Type Substations

The various purposes for which substations are required are such that unit type design and construction can be used. This means, for instance, that for each step-down transformer the design and installation of supporting structure, switches, circuit breakers, lightning arresters, etc., can be the same. The unit may be for a 5000 KVA transformer, and some substations may have one unit while others would have two or three.

It seems apparent that this treatment of substation design has the following advantages:—

1. A tendency to decrease first cost and cost of erection.
2. Readily lends itself to estimate of land requirements for any given present and future installation.
3. Adds considerably to safety for workmen due to fact that arrangement and clearances in all substations of given company would be the same.
4. Reduces necessity for large inventory of replacement parts and makes it possible to procure replacement parts readily from stock of manufacturer who constructed the unit.

In railway service, particularly electrification, the handling of substation work on a unit basis seems particularly fitting because of the reasons enumerated above.

Changes in design of apparatus due to progress in the art may reduce the advantages of unit type construction in providing for future installation.

Conclusion

It is recommended that this subject be continued.

Appendix O

(15) HIGH TENSION CABLES

J. A. Peabody, Chairman, Sub-Committee; J. H. Davis, Vice-Chairman, Sub-Committee; H. C. Griffith, J. T. Seaver, W. M. Vandersluis, L. S. Wells, Sidney Withington.

This Sub-Committee has tentatively considered the following subject:

(a) Collecting information relative to cables as now in service.
(b) Collecting information from publications, societies and manufacturers that has a bearing on the subject.
(c) Determining on a form for tabulating the information.

Progress only can be reported at this time and because of the infancy of the art of conveying high voltage circuits through cables it will not be possible to make any definite recommendations for some time.

(a) Considerable information has already been obtained relative to various installations but most of such information appears to be lacking in certain features. Until a form for recording is definitely decided upon it is useless to try to complete the information.

(b) Some material has been obtained and for the information of the members the following list is given:

National Electric Light Association—Specification for Impregnated Paper Insulated, Lead Covered Underground Cable—1920.
National Electric Light Association—Suggested Specifications for Lead Covered Underground Cable Insulated with Impregnated Paper—1927.
National Electric Light Association—Cable Operation and Underground System Maps and Records—1925-1926.
National Electric Light Association—Inspection on Testing of Cable—1925-1926.
Inspection and Testing of Cable—1927.
American Institute Electrical Engineers—Standard Wires and Cables—1925.
C. C. Knipmeyer—Underground Heat Transfer Tests.
Herman Halperin—Two 66,000 Volt Cables now in Service on Edison System—1926.
(Edison Company to Install Six Mile Line of 132,000 Volt Cable—1926.)
Harry W. Fisher—Methods of Impregnating Cables—1926.
Donald M. Simons—A New 132,000 Volt Cable Joint—1927.
A. M. Meyer—Barrier Type High Voltage Terminal—1926.
Donald M. Simons—Calculation of the Electrical Problems of Transmission by Underground Cables—1925.
Donald M. Simons—Calculation of Current Carrying Capacity of Type H Cables—1926.
F. M. Farmer—Tests of Paper Insulated High Tension Cable—1926.

(c) The settling on a form for recording information has not been found an easy one, as to record all information would be cumbersome and unsatisfactory.

There is some doubt as to what is essential but the following has tentatively been decided on:

- Location
- Owning Company
- Manufacturer
- Type (Single Conductor, etc.)
- Voltage
  - Number of Phases
  - Frequency
  - Operating Voltage
  - Grounded or Ungrounded
- Rating
- Insulation
  - Character
  - Thickness
- Sheathing
- Conductors
  - Number
  - Stranded or Solid
  - Size of each
  - Shape
- Length
- Years in Service

Conclusion

It is recommended that this subject be continued.

REPORT OF COMMITTEE II—BALLAST

Paul Hamilton, *Chairman;*
L. L. Adams,
J. S. Bassett,
G. J. Bell,
C. J. Coon,
W. O. Cudworth,
C. E. Dare,
F. T. Darrow,
C. T. Dike,
R. C. Dunlay,
J. A. Ellis,
A. B. Hillman,
Daniel Hubbard,
E. I. Rogers, *Vice-Chairman;*
A. R. Jones,
A. A. Johnson,
W. J. H. Manning,
E. F. Manson,
J. F. Montgomery,
P. T. Robinson,
W. A. Roderick,
N. H. Self,
H. F. Sharpley,
C. B. Stanton,
A. H. Woerner,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report on the following subjects:

(1) Revision of the Manual.

The report of the Sub-Committee will be found in Appendix A.

(2) Make critical review of the material now appearing in the literature of the Association relating to Ballast; ascertain existing views and practices of the railways; and recommend such changes as are found desirable.

The report of the Sub-Committee on this subject will be found in Appendix B.

(3) Investigate the comparative values of various ballast materials with special reference to drainage and effect on costs for track maintenance, collaborating with Committee I—Roadway.

The report of the Sub-Committee on this subject will be found in Appendix C.

(4) Make critical study of the cause and effect of pumping joints in railway track and the excess cost of maintenance resulting therefrom, with suitable recommendations for removal of cause, collaborating with Committee I—Roadway and Committee V—Track.

The report of the Sub-Committee on this subject will be found in Appendix D.

(5) Investigate and report upon the shrinkage of ballast materials.

The report of the Sub-Committee on this subject will be found in Appendix E.

(6) Outline of work for the ensuing year.

Action Recommended

(1) That the changes in the Manual recommended in Appendix A be approved.

(2) That the report of the Sub-Committee (Appendix B) be received as information.

(3) That the report of the Sub-Committee (Appendix C) be received as a progress report and the subject continued.

(4) That the report of the Sub-Committee (Appendix D) be received as information.

(5) That the report of the Sub-Committee (Appendix C) be received as a progress report.

Recommendations for Future Work

1. Revision of the Manual with particular reference to revision of specifications for washed gravel ballast.
2. Continue study of comparative merits of various ballast materials.
3. Continue study of subject of shrinkage of ballast.

Respectfully submitted,

THE COMMITTEE ON BALLAST,
PAUL HAMILTON, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

C. J. Coon, Chairman, Sub-Committee; C. E. Dare, J. A. Ellis, A. A. Johnson, W. J. H. Manning.

The Committee collaborated with Committee XII—Rules and Organization, with the object of determining what subject-matter now appearing in the Manual under Ballast might properly be incorporated in the work of the Rules and Organization Committee. It was found that the matter on pages 83 to 86 inclusive of the Manual under the caption "Instructions to Govern Ballasting on an Operated Line" should be properly included in the rules to govern conduct of work.

It was agreed that the Committee on Rules and Organization will submit to the Association for approval rules to govern the conduct of ballasting operations.

The Committee recommends that the Instructions to Govern Ballasting on an Operated Line, appearing on pages 83 to 86, inclusive, be eliminated from the Manual upon the adoption by the Association of rules covering this subject presented by Committee XII—Rules and Organization.

No other changes in the Manual are recommended at this time.

Appendix B

(2) MAKE CRITICAL REVIEW OF THE MATERIAL NOW APPEARING IN THE LITERATURE OF THE ASSOCIATION RELATING TO BALLAST; ASCERTAIN EXISTING VIEWS AND PRACTICES OF THE RAILWAYS; AND RECOMMEND SUCH CHANGES AS ARE FOUND DESIRABLE

C. B. Stanton, Chairman, Sub-Committee; W. O. Cudworth, A. R. Jones, W. A. Roderick, H. F. Sharpley.

The Committee sent a questionnaire to the membership of the Association and forty-seven replies thereto have been received.

The following tables are a digest of the replies made by the several railroads:

SECTIONS

Type of Ballast	Number of roads using A.R.E.A. Standard	A.R.E.A. Modified	Their own Section	No answer to question	Type not used
Gravel	8	8	26	1	4
Stone	6	6	25	3	7
Other	4	2	25	4	12

SPECIFICATIONS

Type of Ballast	Number of roads using A.R.E.A. Specifications	A.R.E.A. Modified	Their own Specifications	No answer to question	Type not used
Gravel	9	7	23	4	4
Stone	11	6	20	3	7
Other	4	2	25	12	4

TESTS

Number of roads using recommended tests	11
Number of roads using some of the recommended tests	3
Number of roads not using recommended tests	27
Number of roads making no answer	6

Although very few railroads indicated that they had adopted either the recommended sections or specifications there was the thought expressed by nearly all that the Association's sections and specifications furnished data on which to base the sections or specifications used by the individual road.

The Committee, therefore, recommend that no changes in the sections or specifications be made at this time.

Appendix C

(3) INVESTIGATE THE COMPARATIVE VALUES OF VARIOUS BALLAST MATERIALS, WITH SPECIAL REFERENCE TO DRAINAGE AND EFFECT ON COSTS FOR TRACK MAINTENANCE, COLLABORATING WITH COMMITTEE I—ROADWAY

Daniel Hubbard, Chairman, Sub-Committee; C. T. Dike, A. B. Hillman, Paul Hamilton, A. H. Woerner.

This subject has been studied in collaboration with representatives of Committee I—Roadway.

In connection with the work of the Sub-Committee a questionnaire was sent out to forty-three railroads in the United States. Answers were received from twenty-one of these railroads. The information contained in these answers has been tabulated and is being studied by the Committee.

In making a study of these figures and of conditions on different railroads, considerable variation is found, due to different physical characteristics and density of traffic. The economical use of the various kinds of ballast is almost entirely dependent on these factors.

Where traffic is heavy and subgrade conditions are such that frequent surfacing is not necessary, stone ballast is more economical to use. However, where subgrade conditions are not good and a frequent movement occurs, caused by physical conditions, making necessary frequent working of the track, gravel ballast, which can be worked approximately fifty per cent cheaper and quicker, is much more economical.

Regarding drainage conditions, there is some diversity of opinion as to the economical advantage obtained in the use of stone ballast on heavy coal carrying roads, due to the rapid filling up of voids by small particles of coal and coal dust. This, of course, would only occur within a certain distance of the mines, say 150 miles, as a greater part of the dust will sift out in that distance. This necessitates much more frequent cleaning and the resulting loss of ballast.

The Committee has not attempted to take into consideration the actual cost in dollars and cents, as it does not feel that there has been sufficient time to give this phase of the question proper study.

It is recommended that the study of the subject be continued for another year.

Appendix D

(4) MAKE CRITICAL STUDY OF THE CAUSE AND EFFECT OF PUMPING JOINTS IN RAILWAY TRACK AND THE EXCESS COST OF MAINTENANCE RESULTING THEREFROM, WITH SUITABLE RECOMMENDATIONS FOR REMOVAL OF CAUSE, COLLABORATING WITH COMMITTEE I—ROADWAY, AND COMMITTEE V—TRACK

L. L. Adams, Chairman, Sub-Committee; J. S. Bassett, J. F. Montgomery, P. T. Robinson, N. H. Self.

Representatives from Committee I—Roadway and Committee V—Track, collaborated with the Committee in their work on this subject. This is a very broad subject, and in most cases is governed by local conditions. However, there are a number of general causes for pumping joints, and the effect is always the same.

The general causes can be listed almost entirely under five heads:

(1) Water impounded in roadbed.
(2) Foul ballast.
(3) Creeping rail.
(4) Light rail under heavy traffic.
(5) Improper or insufficient tamping.

The effect of this condition is as follows:

(1) Bad riding track.
(2) Excessive labor maintenance cost.
(3) Excessive damage to ties, rail, and track fastenings.
(4) Unsightly appearance.

The remedies for these conditions in most cases have to be handled individually. However, there are certain general remedies that can be applied.

Committee I—Roadway, has in the past years devoted considerable study to the question of water pockets in roadway, this being closely interlocked with construction of roadway, drainage, deformation of roadbed, and has previously reported as follows:

1921 Manual, page 28, paragraph 40, as revised on page 765 of Volume 27.
1921 Manual, page 57, "Surface and Sub-surface Drainage."
1921 Manual, pages 64 to 66, "Means for Prevention or Cure of Water Pockets in Roadbed," partly revised in Volume 27, paragraph (e), page 787.
Supplement to Manual, Volume 24, Bulletin 249, page 2, "Soft Spots."
Proceedings—Volume 22, beginning on page 714, Appendix E, "Drainage of Large Cuts," with conclusions on pages 716 and 717, and Exhibits on following pages.
Proceedings—Volume 23, "Soft Spots," pages 402 and 403.

Where it is necessary to drain water pockets in roadbed, tiling or some form of pipe drain is considered best, due to "French drains" choking up more quickly than pipe, but each location must be studied separately, as the most economical arrangement in one location may be different from that in another, depending upon availability and cost of pipe, stone, etc.

The roadbed and the track structure on top of it, including the ballast, should be constructed so that the maximum pressure per square foot would not be greater than that which the roadbed would stand. We know approximately the loading applied through the ballast at various depths, so we should select a depth which would evenly distribute this loading and then construct our roadbed to stand that pressure.

It has been observed that water pockets are now in evidence where irregular, wet and rutted conditions existed at time of construction of roadbed. In other words, with grading properly done in accordance with roadway specification; ballast depth designed to meet conditions of roadbed and load; and drainage properly provided for, there should be no "water pockets."

One road has done considerable work in stabilizing the roadbed, the method used in curing water pockets being generally about the same as used on other roads, viz.; putting in French drains or tile to cure the trouble. It has in the last few years done considerable work in stabilizing the roadbed in shallow wet cuts where track was badly affected by water pockets which may be a little out of the ordinary, and that is, driving piling about three feet to six feet beyond the end of ties on each side of track through soft spots. This piling seems to do two things; first, stabilizes the track by acting as a retaining wall on each side of the roadbed, and also breaks up the underlying stratum, which in the case of this road is usually shale, so that some underground drainage is afforded. This method should never be used unless there is an underlying stratum that will act as sub-drainage.

Churning track and pumping joints should not be confused with what is commonly known as soft track, where the roadbed has broken down and water pockets have formed under the track. These spots require almost constant attention and, when cut open show presence of water even in driest weather. The ballast in these pockets is usually found loose, as contrasted with the hard packed ballast where the churning occurs.

Where the ballast has become fouled, either from mud being pumped up through the ballast from the roadbed or from dirt falling on the ballast from any cause, the water will not drain and pumping joints will invariably be the result, in which case it is necessary to clean out all of the foul ballast, and either clean or replace with new, and give the track a substantial raise on the clean ballast. Local conditions will have to determine as to whether the expense of cleaning the ballast is justified. There are at present a number of ballast-cleaning machines on the market that will greatly reduce the cost of this work, and in most cases where the ballast is sufficiently fouled to cause a large number of pumping joints, the expense

of cleaning will be justified, as we have developed that it costs two and one-half to four times as much to maintain track where the joints are pumping badly than where the track is well drained and no signs of pumping occur.

Where track is not properly anchored and the joints are slot-spiked to the joint ties, the creeping of the rail will move the joint ties off of their beds, and this condition will always aggravate and sometimes cause the joints to pump. If, in addition to this, the bolts in the joints are permitted to become loose or worn, the bad condition will be increased. In order to check this movement of the rail, anchors should be applied to such an extent as to reduce the movement of the rail to a minimum.

Where the ends of the rail have become chipped or battered pumping joint are nearly always found. We have a report where one road had twenty miles of track laid with badly battered one-hundred-pound rail, a year ago. Nearly all of the joints in this stretch of track were pumping badly, but were almost entirely cured by building up the rail ends by a welding process, and the labor cost of maintaining this stretch of track before the building up was done was about two and one-half times as much as it has been since the work was completed.

Where a light rail is used under heavy loads, the pressure on the ballast and roadbed is not distributed as it is where heavy rail is used, and this concentration of load causes a churning of the track, and pumping joints are much more likely to develop than where the rail is of sufficient weight to properly carry the load.

Improper or insufficient tamping is a very direct cause of pumping joints. On account of joint construction it is difficult to tamp immediately under the rail at the joints and under the ties next to the joint ties. Very often a ridge of undisturbed ballast ,is left under the rail, especially at the joint, leaving a soft place in the ballast, where water will collect. This, of course, is prevalent over the entire track, but is much more pronounced at the joint, and it has a much more disastrous effect. It is believed that with proper tamping of joints one of the major causes of pumping joints will be eliminated.

Appendix E

(5) INVESTIGATE AND REPORT UPON THE SHRINKAGE OF BALLAST MATERIAL

E. I. Rogers, Chairman, Sub-Committee; G. J. Bell, F. T. Darrow, R. C. Dunlay, E. F. Manson.

Previous consideration of "Shrinkage of Ballast" has been along the lines of determining what percentage should be added to the amount of ballast loosely loaded on cars at point of origin to produce a given ballast section after tamping in track, without having given consideration to any solidification or compacting as a result of the traffic passing over the track.

Certain percentages have heretofore been recommended and same appear on page 6, Volume 26, No. 267, Supplement to the 1921 Manual.

Ballast other than pit run gravel cannot be measured in place at point of origin, so the usual practice is that of measuring the loosely loaded ballast on cars or by weighing. The majority of railroads in handling their ballast, while they may buy it by weight, usually convert it into cubic yards and report it as used and paid for on that basis.

Discussion of this subject has brought out that it is the belief of many that there is no actual shrinkage or loss of ballast between the point of origin and destination if loaded in proper equipment, admitting, however, that there is a loss in the volume, due to the settlement of the ballast in the cars, and that when the ballast is unloaded at destination it again approximately takes the same volume as it had when first loaded.

Two tests conducted by a railroad company, one with gravel ballast and one with broken stone, have come to our attention, and in the case of the washed river gravel, it was found that after transporting same 152 miles, there was a loss of 13.79 per cent in volume, and in the case of the crushed limestone, while there was only a loss in the four cars tested of 190 lb., there was a loss in volume of 13 per cent. These two tests, while for small quantities of ballast, indicate clearly that there is a volumetric shrinkage due to hauling the ballast; these tests also show that the amount of ballast (by measurement) received is dependent upon where and when it was measured, in other words, whether at loading point or at destination. These tests also bring out the fact that considerable care should be exercised as to the determination of the average weight of the cubic yard of ballast which is to be later applied to the aggregate weight of ballast used or purchased, as injustice can be done either the purchaser or seller by measurement at the point of origin where the gravel is loose in the cars or at destination where it has become somewhat compacted. This might become a source of considerable controversy and it is believed that no injustice will be done either the railroad or the contractor if it is

definitely settled where and when measurements are to be taken, for the price will be adjusted to meet the requirements.

There has been no new information received which would lead the Committee to make any recommendations toward changing the percentages as referred to above, which precentages must be taken into consideration and used as only covering the solidification or shrinkage, which takes place in the loosely loaded ballast hauled and placed in the track without consideration being given to traffic moving over the finished track or to an elapsed time after ballasted.

The Committee is attempting now to determine the shrinkage of ballast by comparing the yardage loaded loosely in cars at point of origin, where it is paid for, with the yardage of the same material tamped and compacted in track under the passage of trains. It is of the opinion that this can only be determined by tests being conducted on either old solidified roadbeds or on concrete trestles, and under either of these conditions it will only be possible to secure authentic information by following the ballast material from its source to the track and periodically inspecting, measuring and taking into consideration the tonnage moving over the track. It is hoped that this work can be done the coming year through the co-operation of those roads particularly which will construct new concrete trestles and assist the Committee in handling and securing the data.

Attention is at this time called to the "Shrinkage of Ballast" as it appears on page 84, Volume 27, No. 277, Supplement to the Manual of 1921, as same has been set forth by H. E. Hale, Vice-Chairman of the Eastern Group of the Presidents' Conference Committee.

The Committee is not at this time making any recommendations as to the data therein, but is of the belief that it is very valuable, and calls particular attention to this paragraph:

> "The difficulty of measuring with reasonable accuracy the shrinkage of ballast is due to the usual practice of ballasting a road piecemeal and to the general practice of keeping no record of the location of ballast bought under various contracts from various pits."

The Committee has found this difficulty to exist as stated by Mr. Hale and it is our belief that it can only be overcome by the Committee itself being present when the ballast is weighed or measured, loaded, placed and tamped under the track.

The Committee recommends that this subject be continued for further study.

REPORT OF COMMITTEE XV—IRON AND STEEL STRUCTURES

B. R. Leffler, *Chairman;*
P. S. Baker,
J. E. Bernhardt,
A. W. Carpenter,
O. F. Dalstrom,
R. P. Davis,
F. O. Dufour,
Thos. Earle,
G. H. Gilbert,
G. A. Haggander,
C. S. Heritage,
O. E. Hovey,
J. B. Hunley,
P. G. Lang, Jr.,
W. S. Lacher,
Crosby Miller,
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A. R. Wilson, *Vice-Chairman;*
Albert Reichmann,
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H. N. Rodenbaugh,
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H. B. Stuart,
R. M. Stubbs
G. H. Tinker,
G. H. Trout,
F. E. Turneaure,
F. P. Turner,
H. T. Welty,
W. L. Wilson,
W. M. Wilson,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(9) Punched and Reamed Work (Appendix A).

Action Recommended

(9) That the report on punched and reamed work be received as information (Appendix A).

On Subject No. 1, Revision of Manual, investigations and tests on a number of subjects are under way, including bearing values of large rollers, testing of I-beams in groups, investigation of copper-bearing steel for structural purposes, and tests on columns. The work on these subjects has not progressed far enough to enable the Committee to make any recommendations for revision.

On Subject No. 2, Specifications for Steel Highway Bridges, the Sub-Committee has been in conference with the American Association of State Highway Engineers in drafting a Specification for Highway Bridges. The subject-matter is complete and is in the hands of the editing committee. However, the completed specifications cannot be ready for presentation to the convention this year.

On Subject No. 5, Column Tests, the Committee is collaborating with the Column Committee of the American Society of Civil Engineers, of which Dean Turneaure is chairman. Under the direction of Dean Turneaure, experiments are being made on columns loaded eccentrically. The purpose of these experiments is to determine the longitudinal shearing effect on columns and the necessary strength of lacing. Final report on this subject cannot be made at this time.

On Subject No. 6, Investigation of Copper-Bearing Steel for Structural Purposes, the use of copper-bearing steel for various industrial and structural purposes is increasing; it is now being used in the manufacture of steel cars, tie plates, track spikes, smoke stacks, stationary boilers, metal culvert pipes, metal flashings, ventilators, wire fencing, light structural steel for warehouses, steel sash, power line supports, flood light towers, and overhead electrification structures for railway tracks.

Copper-bearing steel in such service has, in many instances, been found to last twice as long as ordinary steel. It has been little used in railway bridge construction, but records show its use in several important highway bridges. Its application for structural purposes is widening, and its use is now extending to roof trusses in railway shop buildings that are exposed to marked corrosive influences.

Copper-bearing steel can be readily secured at slight increase in cost.

On Subject No. 10, Investigation of Bearing Pressures on Large Rollers, the investigation has brought out much new and valuable information on the bearing values of rollers. Tests to determine the bearing value of large rollers have continued through the year at the University of Illinois. Rolling tests have been made on plates of medium grade steel castings varying in thickness from .5 inches to 4 inches when rolled by cylinders having diameters of 188 inches, 356 inches, and 476 inches.

Funds have been obtained from the Scherzer Rolling Lift Bridge Company which, added to the remainder of the appropriation from the A.R.E.A., enabled the University to employ a half-time graduate research assistant to continue the tests.

A Conference Committee composed of members of Committee XV, and representatives of the American Society of Civil Engineers, are developing Specifications for Steel Railway Bridges. This committee is approaching the completion of its preliminary work and it is quite possible a new specification will be presented to the convention in 1929 as information.

No definite progress was made during the year on the other four subjects of the Committee's Outline of Work given below:

3. Electric welding of connections in steel structures.
4. Investigation and tests of I-beams connected in groups by diaphragms and bracing.
7. Influence of dead load upon the impact from moving loads on bridges.
11. Specifications for steel tanks and their supports for the storage of water and oil—collaborating with Committee XIII.

Recommendations for Future Work

The Committee recommends the reassignment of the following subjects in the form given:

1. Revision of the Manual.
2. Specifications for steel highway bridges.
3. Electric welding of connections in steel structures.

4. Testing of I-beams in groups.
5. Column tests.
6. Investigation of copper-bearing steel for structural purposes.
7. Outline of work for the ensuing year.
8. The influence of the dead load of bridges on the impact from moving loads.
9. Tests on rollers.

Respectfully submitted,

THE COMMITTEE ON IRON AND STEEL STRUCTURES,
B. R. LEFFLER, *Chairman.*

Appendix A

(9) PUNCHED AND REAMED WORK

F. O. Dufour, Chairman, Sub-Committee; Thos. Earle, J. B. Hunley, G. A. Haggander, A. Reichmann, A. F. Robinson, G. H. Tinker, W. L. Wilson.

The Committee makes the following recommendations: That Article XII, Workmanship, in General Specifications for Steel Railway Bridges, as issued August, 1925, Third Edition, be revised and their report be received as information.

For comparison the old and proposed articles are placed in parallel columns.

Present Specifications	*Proposed Specifications*
Class of Work	
206. The work shall be "Punched Work" or "Reamed Work" as stipulated. (Omitted.)	
General	**General**
207. The workmanship and finish shall be equal to the best general practice in modern bridge shops. Material at the shops shall be kept clean and protected from the weather as far as practicable. (No change.)	206. The workmanship and finish shall be equal to the best general practice in modern bridge shops. Material at the shops shall be kept clean and protected from the weather as far as practicable.
Straightening Material	**Straightening Material**
208. Rolled material, before being laid off or worked, must be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Sharp kinks and bends may be cause for rejection. (No change).	207. Rolled material, before being laid off or worked, must be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Sharp kinks and bends may be cause for rejection.
Finish	**Finish**
209. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished. (No change.)	208. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

Present Specifications

Punched Work

210. In punched work, holes in material whose thickness is not greater than the diameter of the rivets plus $\frac{1}{8}$ in. may be punched full size. Holes in material of greater thickness shall be drilled. (Omitted.)

Reamed Work

211. In reamed work, holes in material $\frac{7}{8}$ in. or less, used for lateral, longitudinal and sway bracing, lacing stay plates and diaphragms, may be punched full size. (Practically no change.)

212. Holes in other material $\frac{3}{4}$ in. thick or less shall be sub-punched and reamed. (Changed.)

213. Holes in other material more than $\frac{3}{4}$ in. thick shall be drilled. (Changed.)

Punched Holes

214. Full size punched holes shall be $\frac{1}{16}$ in. larger than the nominal diameter of the rivets. The diameter of the dies shall not exceed the diameter of the punch by more than $\frac{3}{32}$ in. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes must be cleancut, without torn or ragged edges. Poor matching of holes may be cause for rejection. (Changed.)

Sub-Punched and Reamed Holes

215. In sub-punched and reamed work, the holes shall be punched $\frac{3}{16}$ in. smaller and, after assembling, reamed $\frac{1}{16}$ in. larger than the nominal diameter of the rivet. The diameter of the punch used shall be $\frac{3}{16}$ in. smaller than the nominal diameter of the rivet and the diameter of the die not more than $\frac{3}{32}$ in. larger than the diameter of the punch. Outside burrs shall be removed with a tool making a $\frac{1}{16}$ in. fillet. (Changed.)

Accuracy of Punching in Reamed Work

216. In sub-punched and reamed work, the punching shall be so accurately done that, after assembling

Proposed Specifications

Punching and Reaming

209. All main material, forming parts of a member composed of not more than 5 thicknesses of metal, may be punched with a punch $\frac{1}{16}$ in. larger than the nominal size of the rivets, whenever the thickness of the metal is not greater than $\frac{5}{8}$ in. When there are more than 5 thicknesses, or when any of the main material is thicker than $\frac{5}{8}$ in., all of the holes shall be punched with a punch $\frac{3}{16}$ in. smaller, and after assembling reamed $\frac{1}{16}$ in. larger than the nominal size of the rivets, except that when the metal is thicker than the size of the rivet minus $\frac{1}{8}$ in., the holes shall be drilled.

210. Holes in material $\frac{7}{8}$ in. or less, used for lateral, longitudinal and sway bracing, lacing, stay plates and diaphragms, may be punched with a punch $\frac{1}{16}$ in. larger than the nominal size of the rivet.

211. The diameter of the die shall not exceed the diameter of the punch by more than $\frac{3}{32}$ in. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes must be clean cut, without torn or ragged edges. Poor matching of holes may be cause for rejection.

Present Specifications

and before reaming, a cylindrical pin $\frac{1}{8}$ in. smaller in diameter than the nominal size of the punched hole may be entered, perpendicular to the face of the member, without drifting, in at least 75 of any group of 100 contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces shall be rejected. If any hole will not pass a pin $\frac{3}{16}$ in. smaller in diameter than the nominal size of the punched hole, this shall be cause for rejection. (Omitted.)

Reaming After Assembling

217. Reaming shall be done after the pieces forming a built member are assembled and so firmly bolted together that the surfaces are in close contact. Before riveting, they shall be taken apart if necessary and any shavings removed. When it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. (Practically no change.)

Accuracy of Reaming and Drilling

218. When holes are reamed or drilled, 85 of any group of 100 contiguous holes in the same plane shall, after reaming or drilling, show no offset greater than $\frac{1}{32}$ in. between adjacent thicknesses of metal. (Omitted.)

Reamed Holes

219. Reamed holes shall be cylindrical, perpendicular to the member, and not more than $\frac{3}{32}$ in. larger than the nominal diameter of the rivets. Reamers preferably shall not be directed by hand. Outside burrs shall be removed with a tool making a $\frac{1}{16}$ in. fillet. (Changed.)

Drilled Holes

220. Drilled holes shall be $\frac{1}{16}$ in. larger than the nominal size of the rivet. Burrs on the outside surfaces shall be removed. (Changed.)

Proposed Specifications

Reaming After Assembling

212. Reaming shall be done after the pieces forming a built member are assembled and so firmly bolted together that the surfaces are in close contact. Burrs on the outside surface shall be removed. The pieces shall be taken apart before riveting, if necessary, and any shavings removed. When it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted.

213. The holes shall be cylindrical, perpendicular to the member, and not more than $\frac{1}{16}$ in. larger than the nominal diameter of the rivets. Reamers preferably shall not be directed by hand.

Drilled Holes

214. Drilled holes shall be $\frac{1}{16}$ in. larger than the nominal size of the rivet. Burrs on the outside surfaces shall be removed. Drilling

Present Specifications

Assembling for Drilling

221. Connecting parts requiring drilled holes shall be assembled and securely held together while being drilled. (Omitted.)

Shop Assembling

222. The parts of riveted members shall be well pinned and firmly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. Surfaces in contact shall be painted. Bolts in field connection holes shall be left in place. (Slight change.)

Field Connections

223. Solid floor sections shall be assembled to the girders or trusses, or to suitable frames, in the shop, and the end connections made to fit. (No change.)

224. In reamed work, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and the holes for field connections drilled or reamed while so assembled. Holes for other field connections, except those in lateral, longitudinal and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal template. (Changed.)

225. In punched work, the field connections (except those in lateral, longitudinal and sway bracing) shall be reamed to metal templates. (Omitted.)

Match-Marking

226. Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished the Engineer. (No change.)

Proposed Specifications

shall be accurately done and poor matching of holes may be cause for rejection.

Reaming and Drilling

215. Reaming and drilling shall be done with twist drills.

Shop Assembling

216. The parts of riveted members shall be well pinned and firmly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal.

Field Connections

217. Solid floor sections shall be assembled to the girders or trusses, or to suitable frames, in the shop, and the end connections made to fit.

218. Riveted trusses shall be assembled in the shop to line and fit and the holes for field connections drilled or reamed while so assembled, or these connections may be reamed to proper metal templates so placed as to result in fair holes for the connections. Holes for other field connections, except those in lateral, longitudinal and sway bracing, shall be reamed or drilled to a metal template.

Match-Marking

219. Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished the Engineer.

Present Specifications

Rivets

227. The size of rivets called for on the plans shall be the size of the rivet before heating. (No change.)

228. Rivet heads, when not countersunk or flattened, shall be of approved shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member. (Slight change.)

Riveting

229. Rivets shall be heated uniformly to a light cherry red and driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale, and carbon deposit. When driven, they shall completely fill the holes. Loose, burned, or otherwise defective rivets shall be replaced. In removing rivets care shall be taken not to injure the adjacent metal, and if necessary, they shall be drilled out. Caulking or recupping will not be permitted. (Slight change.)

230. Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed. (No change.)

231. When necessary to drive rivets with a pneumatic riveting hammer, a pneumatic bucker shall be used for holding up, when practicable. (Slight change.)

Field Rivets

232. Field rivets shall be furnished in excess of the nominal number required to the amount of 15%, plus ten rivets, for each size and length. (No change.)

233. Field rivets shall be carefully selected, and shall be free from fins on the under side of the head. (Slight change.)

Turned Bolts

234. Where turned bolts are used to transmit shear, the holes shall be reamed parallel and the bolts shall make a tight fit with the threads entirely outside of the holes. A washer not less than ¼ in. thick shall be used under each nut. (No change.)

Proposed Specifications

Rivets

220. The size of rivets called for on the plans shall be the size of the rivet before heating.

221. Rivet heads shall be of approved shape and of uniform size for the same diameter of rivet. They shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

Riveting

222. Rivets shall be heated uniformly to a light cherry red and driven while hot. They shall be free from slag, scale, and carbon deposit. When driven, they shall completely fill the holes. Loose, burned, or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal and, if necessary, they shall be drilled out. Caulking or recupping will not be permitted.

223. Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed.

224. When rivets are driven with a pneumatic riveting hammer, a pneumatic bucker shall be used for holding up, when practicable.

Field Rivets

225. Field rivets shall be furnished in excess of the nominal number required to the amount of 15 per cent, plus ten rivets, for each size and length.

226. Field rivets shall be free from fins on the under side of the head.

Turned Bolts

227. Where turned bolts are used to transmit shear, the holes shall be reamed parallel and the bolts shall make a tight fit with the threads entirely outside of the holes. A washer not less than ¼ in. thick shall be used under each nut.

Present Specifications

Planing Sheared Edges

235. Sheared edges of material more than ⅝ in. thick and carrying calculated stress shall be planed to a depth of ¼ in. Reentrant cuts shall be filleted before cutting. (Changed.)

Lacing Bars

236. The ends of lacing bars shall be neatly rounded, unless otherwise called for. (No change.)

Fit of Stiffeners

237. Stiffeners under the top flanges of deck girders and at all bearing points shall be milled or ground to bear against the flange angles. Other stiffeners must fit sufficiently tight against the flange angles to exclude water after being painted. Fillers and splice plates shall fit within ¼ in. at each end. (No change.)

Web Plates

238. Web plates of girders which have no cover plates may be ⅛ in. above or below the backs of the top flange angles. Web plates of girders which have cover plates may be ½ in. less in width than the distance back to back of flange angles. (No change.)

239. When web plates are spliced, not more than ⅜ in. clearance between ends of plates will be allowed. (No change.)

Facing Floor Beams, Stringers and Girders

240. Floor beams, stringers and girders having end connection angles shall be made of exact length after the connection angles are riveted. If facing is necessary, the thickness of the angles shall not be reduced more than ⅛ in. at any point. (Changed.)

Finished Members

241. Finished members shall be true to line and free from twists, bends and open joints. (No change.)

Abutting Joints

242. Abutting joints in compression members and girder flanges, and where so specified on the drawings, in tension members, shall be faced and brought to an even bearing. Where joints are not faced,

Proposed Specifications

Planing Sheared Edges

228. Sheared edges of material more than ¾ in. thick and carrying calculated stress shall be planed to a depth of ¼ in. Reentrant cuts shall be filleted before cutting.

Lacing Bars

229. The ends of lacing bars shall be neatly rounded, unless otherwise called for.

Fit of Stiffeners

230. Stiffeners under the top flanges of deck girders and at all bearing points shall be milled or ground to bear against the flange angles. Other stiffeners must fit sufficiently tight against the flange angles to exclude water after being painted. Fillers and splice plates shall fit within ¼ in. at each end.

Web Plates

231. Web plates of girders which have no cover plates may be ⅛ in. above or below the backs of the top flange angles. Web plates of girders which have cover plates may be ½ in. less in width than the distance back to back of flange angles.

232. When web plates are spliced, not more than ⅜ in. clearance between ends of plates will be allowed.

Facing Floor Beams, Stringers and Girders

233. Floor beams, stringers and girders having end connection angles shall be made of exact length. If facing is necessary, the thickness of the end connection angles shall not be reduced more than ⅛ in. at any point.

Finished Members

234. Finished members shall be true to line and free from twists, bends and open joints.

Abutting Joints

235. Joints in compression members and girder flanges, and where so specified on the drawings, in tension members, shall have the abutting surfaces faced and brought to an even bearing. Where joints are not

Present Specifications

the opening shall not exceed ¼ in. (Practically no change.)

Eye-Bars

243. Eye-bars shall be straight, true to size, and free from twists, folds in the neck or head, and other defects. The heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of the heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the Engineer. The thickness of the head and neck shall not overrun more than $\frac{1}{16}$ in. for bars 8 in. or less in width, ⅛ in. for bars more than 8 in. and not more than 12 in. in width, and $\frac{3}{16}$ in. for bars more than 12 in. in width. (Changed.)

244. Eye-bars which are to be placed side by side in the structure shall be bored so accurately that, upon being placed together, the pins will pass through the holes at both ends at the same time without driving. Eye-bars shall have both ends bored at the same time. (No change.)

Annealing

245. Eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling. Proper instruments shall be provided for determining at all times the temperature of the bars. (No change.)

246. Other steel which has been partially heated shall be annealed except where used in minor parts. (No change.)

Boring Pin Holes

247. Pin holes shall be bored true to gage, smooth, straight, at right angles with the axis of the member and parallel with each other, unless otherwise required. The variation from the specified distance from outside to outside of pin holes in tension members, or from inside to inside of pin holes in compression members, shall not exceed $\frac{1}{32}$ in. In built-up members the boring shall be done after the member is riveted. (Changed.)

Proposed Specifications

faced, the opening shall not exceed ¼ in.

Eye-Bars

236. Eye-bars shall be straight true to size, and free from twists, folds in the neck or head, and other defects. The heads shall be made by upsetting, and rolling or forging. Welding will not be allowed. The thickness of the head and neck shall not overrun more than $\frac{1}{16}$ in. for bars 8 in. or less in width, ⅛ in. for bars more than 8 in. and not more than 12 in. in width, and $\frac{3}{16}$ in. for bars more than 12 in. in width.

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Annealing

238. Eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling. Proper instruments shall be provided for determining at all times the temperature of the bars.

239. Other steel which has been partially heated shall be annealed except where used in minor parts.

Boring Pin Holes

240. Pin holes shall be bored true to gage, smooth, straight at right angles with the axis of the member and parallel with each other, unless otherwise required. The variation from the specified distance from outside to outside of pin holes in tension members, or from inside to inside of pin holes in compression members, shall not exceed $\frac{1}{32}$ in. for each 75 ft. or fraction thereof in length. In built-up members the boring shall be done after the member is riveted.

Present Specifications

Boring Pins

248. Pins more than 9 in. in diameter shall have a hole bored longitudinally through the center of each not less than 2 in. in diameter. (No change.)

Pin Clearances

249. The difference in diameter between the pin and the pin hole shall be 1/50 in. for pins up to 5 in. in diameter and $\frac{1}{32}$ in. for larger pins. (No change.)

Pins and Rollers

250. Pins and rollers shall be accurately turned to gage and shall be straight, smooth and free from flaws. (No change.)

Screw Threads

251. Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for pin ends of diameters greater than 1⅜ in. they shall be made with six threads to an inch. (No change.)

Welds

252. Welds in steel will not be allowed, except to remedy minor defects. (Omitted.)

Forging Pins

253. Pins more than 7 in. in diameter shall be forged and annealed. (No change.)

Bearing Surfaces Planed

254. The top and the bottom surfaces of base and cap plates of columns and pedestals, except those in contact with masonry, shall be planed, or hot-straightened, and parts of members in contact with them shall be faced to fit. Connection angles for base plates and cap plates shall be riveted to compression members before the members are faced. (Changed.)

255. Sole plates of plate girders shall have full contact with the girder flanges. Sole plates and masonry plates shall be planed or hot-straightened. Cast pedestals shall be planed on the surfaces in contact with steel and shall have the bottom surfaces resting on masonry rough finished. (Changed.)

Pilot Nuts

256. Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified. (No change.)

Proposed Specifications

Boring Pins

241. Pins more than 9 in. in diameter shall have a hole bored longitudinally through the center of each not less than 2 in. in diameter.

Pin Clearances

242. The difference in diameter between the pin and the pin hole shall be 1/50 in. for pins up to 5 in. in diameter, and $\frac{1}{32}$ in. for larger pins.

Pins and Rollers

243. Pins and rollers shall be accurately turned to gage and shall be straight, smooth and free from flaws.

Screw Threads

244. Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for pin ends of diameters greater than 1⅜ in. they shall be made with six threads to an inch.

Forging Pins

245. Pins more than 7 in. in diameter shall be forged and annealed.

Bearing Surfaces Planed

246. The top and bottom surfaces of base and cap plates of columns and pedestals shall be planed, or hot-straightened, and parts of members in contact with them shall be faced to fit. Connection angles for base plates and cap plates shall be riveted to compression members before the members are faced.

247. Sole plates of plate girders shall have full contact with the girder flanges. Sole plates and masonry plates shall be planed or hot-straightened. Cast pedestals shall be planed on the surfaces in contact with steel and on surfaces resting on masonry.

Pilot Nuts

248. Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified.

REPORT OF COMMITTEE XXIII—SHOPS AND LOCOMOTIVE TERMINALS

F. E. Morrow, *Chairman;*
A. L. Atwill,
C. N. Bainbridge,
Leland Clapper,
N. Corey,
J. H. Davison,
K. B. Duncan,
E. A. Dougherty,
Geo. W. Hand,
C. D. Harding,
C. E. Harris,
G. W. Harris,
J. L. Haugh,
R. J. Hammond,
Daniel Hillman,
C. A. Hornecker,
A. T. Hawk, *Vice-Chairman;*
L. P. Kimball,
W. H. Kirkbride,
W. T. Krausch,
H. C. Lorenz,
J. S. McBride,
J. M. Metcalf,
D. A. Porter,
V. B. W. Poulsen,
W. A. Radspinner,
J. W. Raitt,
John Schofield,
L. K. Sillcox,
B. S. Voorhees,
H. W. Williams,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Locomotive Coaling Stations (Appendix A).
(2) Methods for the Safe and Convenient Storage of Crude and Fuel Oil and Oil Reclaiming Sumps (Appendix B).

Action Recommended

(1) That the conclusions and typical specifications for mechanical type coaling stations in Appendix A be approved for publication in the Manual.
(2) That report in Appendix B be received as information only.

Recommendations for Future Work

1. Revision of Manual.
2. Continue the study of design for:
   (a) Coaling stations,
   (b) Typical locomotive repair shops,
   (c) Storehouses,
   (d) Shops and locomotive terminals

with particular reference to convenience and economy of operation, collaborating with Committee VI—Buildings.

3. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Shops and Terminals,
F. E. Morrow, *Chairman.*

Appendix A

(2-a) LOCOMOTIVE COALING STATIONS

L. P. Kimball, Chairman, Sub-Committee; A. L. Atwill, C. N. Bainbridge, J. H. Davison, C. D. Harding, J. L. Haugh, Leland Clapper, H. C. Lorenz, J. S. McBride, E. A. Dougherty, V. B. W. Poulsen, J. W. Raitt, John Schofield, R. J. Hammond.

It is now a well-established practice among the railways generally to use a mechanical type of coaling station, and for that reason this report will be confined to installations of that type. A mechanical coaling station should be understood as one consisting of an unloading hopper and some form of mechanically operated conveying machinery for elevating the coal and delivering same to locomotive tenders either directly or through storage bins.

Again recognizing the well-established practice of a majority of the railways to purchase coaling stations completely installed, including structures and mechanical features from contractors specializing in that character of work, it will be the purpose of this report to outline the requirements for such projects and develop a typical specification, which, when amplified to fill the requirements of a particular installation, will serve as a basis for securing competitive proposals that are on a comparative scale, and which will also be a guide for the checking of detailed working drawings which are prepared by the successful contractor after the award of contract.

In addition to any typical specification which can be developed it will be necessary to give consideration for each installation to a number of items which must be developed to suit the individual requirements of the location.

Photographs of several modern coaling stations of concrete construction which are typical of the recommendations in this report are included herewith.

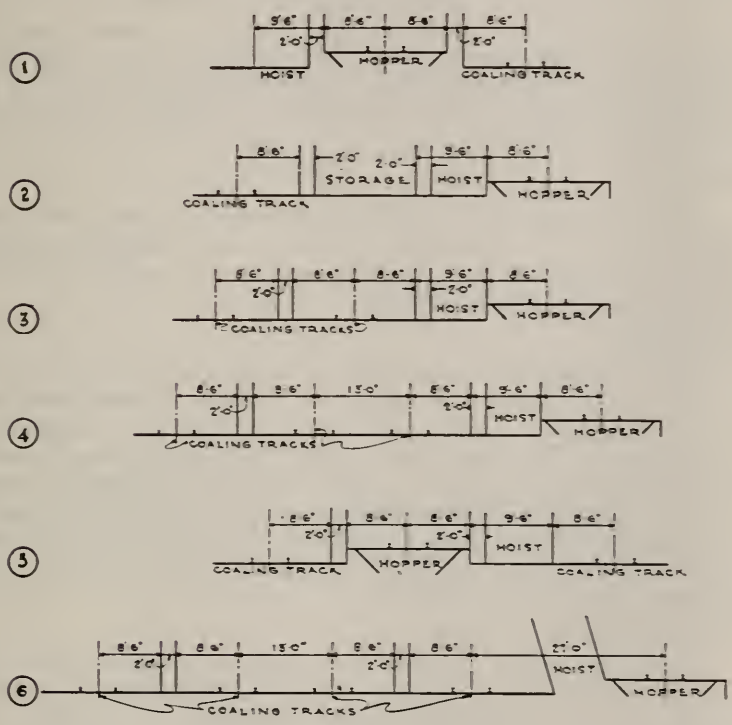
Conclusions

Location

The location of coaling station should, of course, be selected with a view to serving the best interests from an operating standpoint. There are two general classes of locations for coaling stations, those at terminals and those at roadside locations between terminals. At terminals coaling stations should be located so as to serve both inbound and outbound tracks as recommended for engine terminal layout.

Track Layout

The mechanical coaling station can readily be arranged to deliver coal on one, two, three, four or even more tracks. Each location should be studied separately and the most suitable arrangement for that particular installation selected. A number of combinations which can be used, and which will provide suitable clearances and space for elevating equipment, are shown below.


1
9'6"
8'6"
8'6"
8'6"
2'0"
2'0"
HOIST
HOPPER
COALING TRACK
2
8'6"
2'0"
2'0"
9'6"
8'6"
STORAGE
HOIST
HOPPER
COALING TRACK
3
9'6"
8'6"
8'6"
9'6"
8'6"
2'0"
2'0"
HOIST
HOPPER
COALING TRACKS
4
8'6"
9'6"
15'0"
8'6"
9'6"
8'6"
2'0"
2'0"
HOIST
HOPPER
COALING TRACKS
5
8'6"
8'6"
8'6"
9'6"
8'6"
2'0"
2'0"
HOIST
HOPPER
COALING TRACK
COALING TRACK
6
8'6"
8'6"
15'0"
8'6"
8'6"
2'0"
2'0"
21'0"
HOIST
HOPPER
COALING TRACKS

Hopper and Unloading Track

Except in cases where coal is delivered direct to locomotives without the use of a storage bin, the unloading hopper should be at least twenty (20′) feet in length and in larger installations it is desirable to use a greater length to secure additional storage before elevation and to avoid the necessity of accurate spotting of cars. In some very small plants where hopper bottom cars are used a less length of hopper may be justified to save construction cost. In some larger installations it may be desirable to use two unloading hoppers, in which case they should be on separate tracks. The unloading track or tracks should have a capacity both for loaded and for empty cars equivalent to the capacity of the storage bins. This will permit the operation with only one shifting of cars in each 24 hours and will thereby avoid any interruption to the unloading and elevation of coal.

Car Haul

It is usually desirable and convenient for use in spotting of cars over track hopper to have a mechanically operated car puller either as a separate unit or in conjunction with the hoisting equipment, and specifications should state definitely just what is required.

Storage Bins

The bins should have a total capacity at least equal to the consumption in 36 hours, and separate bins should be provided for different grades of coal where required. Except in cases of very small storage capacity it is good practice to divide the storage space into two bins even where different grades of coal are not handled. This will permit the cleaning or repair of a bin without affecting the operation of the coaling station seriously, and will also be desirable in the event of any future requirements for more than one grade of coal. Storage of coal in unused pockets should be prevented on account of fire hazards.

Hoisting Capacity

The hoisting capacity of the elevating machinery should be such as to permit the elevation of an entire 24 hours consumption during one eight (8) hour shift. In large and important stations it may be desirable to divide the hoisting capacity into two units to guard against breakdowns.

Power

Electricity for power purposes is yearly becoming available at an increasing number of locations. Where available its use should be adopted and the particular characteristics of the current to be used should be given. At locations where electricity cannot be secured, steam or internal combustion engines may be used and the particular one desired should be specified together with the requirements for the handling and storage of fuel.

Material of Construction

Coaling stations may be constructed of wood, steel or concrete materials, but in any case the particular materials selected should be specified.

Crushers and Breaker Bars

Where coal in proper sizes cannot be obtained from mines, or when it is not economical to do so, provision should be made for the installation of crushers or breaker bars. Specifications should state type and capacity of crusher required, and whether it is desired to locate same in hopper or over bins. Location in hopper is generally preferred as this eliminates the necessity of carrying a heavy load with considerable vibration high up in the structure but it usually involves the use of an additional horizontal conveyor unit to avoid an abnormally deep pit.

Scales

Where accounting requirements are such that an accurate record must be kept of the amount of coal delivered to each locomotive, scales should be provided for that purpose. This can best be accomplished by the use of a small weigh hopper supported on scale levers over each delivery spout. Capacity of hopper should be slightly greater than the largest amount issued to a locomotive at one time.

Interior Chutes

Where conditions make it desirable to prevent, as far as possible, the breaking up of lump coal and the separation of lump and slack, provision should be made in the specifications for the installation of special chutes or other means of preventing long drops when discharged from conveyor into storage bins.

Housing

Vertical or inclined shaft for elevating equipment may be housed or not as desired. Specifications should definitely state whether or not housing is required, and if required the materials to be used should be fully described. It is usually the practice to provide a housing over unloading hopper if same is not so arranged as to be protected by the structure of the bins. Specifications should definitely state whether or not such a housing is required and if desired the materials to be used should be described.

Sanding Facilities

As it is usually desirable from an operating standpoint to supply locomotives with coal and sand at the same time, it is usual to provide with most coaling stations some character of sanding facilities. The importance of such facilities, no doubt, justifies their consideration in a separate and more detailed report but when combined with a coaling station project the specifications should provide for the requirement of unloading, storing and drying of green sand and for the elevating, storing and delivery of dry sand to locomotives.

Electrical Work

Electric wiring for light and power service is usually eliminated from coaling station contract work and handled by the railroad's own

organization or on separate contract. Specifications should state definitely, however, as to this feature, so that contractors may understand whether or not electrical work should be included. In the event that same is to be included in the contract the specifications should describe in detail the extent and character of the work required.

TYPICAL SPECIFICATIONS FOR COALING STATIONS—MECHANICAL TYPE

General

These specifications are intended to cover the special features which will be required in connection with the design and construction of coaling stations. They shall be used with special specifications prepared for a particular installation, and also with the specifications of the American Railway Engineering Association for buildings, masonry, iron and steel structures and wooden bridges and trestles for items of structural design, character of materials and execution of work in so far as they apply.

Intent

It is the intention of these specifications to provide for the design and construction of a complete automatic coaling station of such type of construction as may be specified, notwithstanding any omissions in these specifications.

Type of Construction

Storage bins and supports, hoist tower, and machinery house shall be constructed of timber, structural steel, or concrete, or a combination of same, as may be indicated in special specifications for particular installation. Foundations and hopper pit shall be of concrete construction, and in the event any all steel or concrete superstructure is specified no wood of any kind will be permitted in the finished structure.

Description of Plant

The plant shall consist of an unloading hopper or hoppers into which coal may be unloaded from cars and mechanically operated conveying equipment for elevating coal and bins for storing same and delivering to locomotives by gravity. The design of the plant shall be such that its operation is entirely automatic and that once the elevation of coal is commenced the operation shall be continuous without further attention on the part of operator to the elevating equipment until it is desired to stop the operation.

Design

Unit stresses used in design shall be in accordance with American Railway Engineering Association requirements as previously specified. As a basis for proposal unless otherwise specified an allowable soil bearing pressure of 3,000 pounds per square foot shall be used. All foundations shall be carried at least four feet below base of rail of adjacent tracks. Wind load shall be assumed at 30 pounds per square foot acting horizontally in any direction.

Track Arrangement

The required arrangement of hopper track and coaling tracks for which the plant must be designed is shown on location plan accompanying these specifications.

Storage Bins

Storage bins of the number and capacity required by the special specifications shall be provided and the capacity specified must be obtained without any trimming or handling of coal in bins. The sloping surfaces of bins shall be at least 45 degrees and all valleys and ridges shall be rounded to a radius of at least 18 inches.

In steel superstructures side plates of storage bins shall have a minimum thickness of ¼ inch and bottom plates ⅜ inch. In wood superstructures floor shall be lined with $\frac{3}{16}$ inch steel plates, and side walls for full height of bin with No. 10 gage steel plates. Steel plate lining shall be securely fastened in place with countersunk flat head screws and shall be accurately fitted to slope of bin and gates and shall be properly curved at valleys and ridges.

Clearances

The design shall be such that when delivery chutes are raised all parts of the structure shall have clearances to tracks at least the equivalent of those adopted by the Association in the General Specifications for Steel Railway Bridges, unless otherwise prescribed in special specifications or required by any law.

Unloading Hopper

The unloading hopper shall be of concrete construction 16′0″ wide and at least 20′0″ long in clear. The slopes shall be at least 10 inches vertical in 12 inches horizontal and all valleys shall be rounded to a radius of at least 18 inches. The lines of intersection of the side walls of the pit with the sloping floor of same shall be such that there will be at least 18 inches clearance below bottom of any track beam or breaker bars to the surface of the hopper. The unloading track shall be carried over the hopper on a structural steel beam under each rail, preferably spanning the entire length of the hopper. If an intermediate support is necessary a steel cross girder rather than a masonry pier shall be used. Rail will be installed by the Railroad Company. The level of the unloading track at the unloading hopper shall, unless otherwise specified, be at least two feet above that of the coaling tracks. The Contractor shall waterproof the hopper and the hoist pit and shall guarantee this waterproofing for a period of at least one year after the acceptance of the plant.

Collision Walls

Frame work supporting storage bins, where adjacent to coaling tracks, shall be protected by means of a concrete collision wall extending the full length of the structure and to a point 4 ft. 0 in. beyond center line of supporting column at each end, at least 2 ft. 0 in. thick and extending to a

height of 6 ft. 0 in. above the top of rail of coaling tracks. Openings shall be provided in these collision walls as required to permit the convenient salvaging of coal wasted off of tenders. These walls must have clearances as hereinbefore specified.

Screening and Separation

Each coaling station shall be provided with bar screen over bins, bars to be spaced about two inches apart to permit the separation of lumps and screenings in run-of-mine coal and shall further be provided with chutes and gates which will permit the delivery of any grade of coal to any bin. Operating mechanism for the control of these gates, screens, etc., shall be placed in convenient location at track level.

Ladders, Stairways, etc.

The Contractor shall provide ladders on the outside of the structure with the necessary platforms and railings to enable the operator to reach each gate, outside sheave, sand spout and sand pipe turn for repairing, oiling, or any other purpose. He shall also provide ladders on the inside of the bins so that the operator may be able to reach the bottom of each bin at each gate. He shall also provide a suitable stairway located where most convenient and extending from the track level to the top of hoist tower. All stairways, platforms and landings, either inside or outside of structure shall be provided with suitable railings and approved open grating treads. Open grating walkways 2 feet wide shall be provided on each side of unloading hopper, of an approved type.

Windows and Doors

The Contractor shall install necessary doors to provide access to structure and such pivoted steel windows as are necessary to afford ample light in all parts of the plant for the purpose of general inspection and safe performance of operator's duties.

For concrete and steel superstructure all windows and doors shall be of metal construction and glazed with wire glass.

Coaling Fixtures

The Contractor shall install, for the delivery of coal from each storage bin to each coaling track, a steel chute and gate of approved design. Each chute shall be equipped with an apron and baffle plate arranged so that fall of coal after leaving chute will be vertical and over center line of coaling track.

Chutes and gates shall be counterweighted and designed and installed in such a way as to permit of same being operated by one man when standing on top of locomotive tender or on overhead platform if provided. Counterweights shall be so adjusted that gate and chute will close and return to normal position when released by the operator. All outside parts of mechanism shall be hooded or otherwise protected against freezing. Hand hole shall be provided in side of chute between each gate and bin wall. Chutes when in low position shall be not less than 15 ft. 6 in. above top of rail.

Power

The power to be used for operation of equipment shall be as provided in special specifications. In the event electric power is used the electrical equipment furnished shall conform to the characteristics of current as specified.

Hoisting Equipment

The hoisting equipment, which shall be furnished and installed by the Contractor, shall be entirely capable of hoisting the quantity of coal per hour as required by special specifications, without undue crowding, overloading or forcing. The hoist and power units shall be placed upon suitable concrete foundations and shall be placed at such an elevation as to allow ample clearance for gears, fly wheels and belting. All gearing and exposed parts and belting shall be protected in an approved manner by means of neat and substantial guards or railings so that operator will not be exposed to any danger from moving machinery. All machinery and other equipment shall be assembled and installed in a thorough and workmanlike manner. The transmission equipment and cables between hoist and hoisting tower shall be securely housed to provide adequate protection from weather.

Electrical Equipment

Electrical equipment and wiring shall be designed to operate with current of the kind and voltage as stated in special specifications. Electric service will be brought to the machinery house and connected to a main service switch by the Railroad. Wiring for lighting will also be done by the Railroad unless otherwise specified. Installation of motor, control and all other necessary wiring and accessories to make a complete and satisfactory installation shall be furnished and installed by the Contractor. The rigid conduit system of wiring construction shall be used. Conduit shall be either sherardized or galvanized. Thirty per cent rubber compound insulated wire of approved brands shall be used for all wire having rubber insulation. All work must conform to the requirements of the National Board of Fire Underwriters, local municipal building codes and any special regulations of the lighting service company that may be in effect. Motors shall have proper speed and torque characteristics for the service for which they will be used. They shall have anti-friction bearings and insulation suitably impregnated to withstand moisture, coal dust, etc. If motor is located where it is subjected to excessive coal dust conditions, it shall be of the enclosed type. Control shall be of the magnetic type with all necessary accessories for proper operation of the equipment, equipped with undervoltage protection, overload protection of the temperature overload relay type, necessary push button stations, limit switches, etc. Control shall be of the type that will limit starting currents to values permitted by the local central station company supplying the electric service. Make and type of motors, control, and accessories to be used shall be approved by the Railroad Company.

Plans to Accompany Proposal

Each bidder shall accompany his proposal with plans and descriptions in sufficient detail to indicate just what arrangement is intended to be furnished and proposal may also be accompanied by photographs of similar structure.

Plans to be Furnished by the Contractor

Immediately upon being awarded the contract, the successful Contractor shall prepare complete detail drawings of all parts of the structure and equipment, including machinery, buckets, gates, stairs, ladders, piping and wiring diagrams, if necessary. These plans shall be submitted in triplicate to the Engineer for approval, and upon completion of the work, the Contractor shall furnish a complete set of original or reproduced tracings on cloth of all drawings, which shall be a true record of the structure and equipment as built and installed. He shall also furnish, in triplicate, a complete list of all parts of machinery with pattern numbers or other designation to permit the ready ordering of repair parts. One of these lists shall be framed and glazed and hung in prominent location in machinery house.

Guarantee

The Contractor will be held solely responsible for the design of the coaling station and equipment in accordance with these specifications, and the checking and approval of plans by the Engineer will not relieve him of this responsibility. The Contractor shall guarantee the perfect operation of the entire plant and equipment for a period of one year after the completion and acceptance and shall agree to make good at his own expense, any defects which may develop within that time, due to faulty design, workmanship or materials, and not caused by carelessness or improper handling on the part of the Railroad. The Contractor shall furnish a competent mechanic to instruct the Railroad's operator for at least one week after the plant is placed in operation.

Roadside Coaling Station. Storage 500 Tons of Coal, 400 Tons of Sand. Delivery on Three Tracks.

Terminal Coaling Station. 1000 Tons Storage. Delivery on Six Tracks.

Roadside Coaling Station. Storage 500 Tons. Delivery on Three Tracks.

Roadside Coaling Station. Storage 650 Tons. Delivery on Five Tracks.

Terminal Coaling Station. Storage 500 Tons. Delivery on Three Tracks.

Roadside Coaling Station. Storage 500 Tons. Delivery on Four Tracks.

Appendix B

(3) METHODS FOR THE SAFE AND CONVENIENT STORAGE OF CRUDE AND FUEL OILS

J. M. Metcalf, Chairman, Sub-Committee; F. E. Morrow, C. N. Bainbridge, K. B. Duncan, G. W. Hand, G. W. Harris, C. A. Hornecker, W. H. Kirkbride, D. A. Porter.

The most common method of large storage of crude and fuel oils, as well as the lighter petroleum products, is in steel tanks. Tanks of 37,500, 55,000 and 80,000 barrels capacity are standard sizes with the manufacturers and are in general use both by the oil companies and by the fuel oil using railways. There has been some use, for larger storage, of earthen and concrete tanks by some oil companies, but the steel tanks are generally standard in the industry as among the railroads. The various practices as to tank roofs and the design of protecting dikes around tanks were discussed in detail in the report of this Committee to the 1927 convention of the Association.

The danger of fire loss in stored oil varies with the character of the oils. The more volatile refined oils and some crude oils having an unstable mixture of the lighter elements are not only more readily inflammable but present a greater hazard when stored in other than gas-tight receptacles, on account of the presence on the surface and in the vicinity of the tank of inflammable gases resulting from evaporation. For such oils the all-steel tank with floating or other gas-tight roof affords the best protection against lightning or other fire risk. The increasing use of such tanks by oil companies and others is evidence of belief that the greater cost is justified by the added protection and reduction in loss by evaporation. Some western railroads using more readily inflammable oil report extensive use of floating roofs of various designs, the most recent installations being of the "pontoon" or non-sinkable type.

The residuum fuel oils in common use as locomotive fuel by the railways contain little volatile matter and offer comparatively little risk of loss by fire. Replies to questionnaire indicate that the railroads generally, which are using oil of this character, are installing no special devices for lightning protection and have had, over a series of years, practically no loss by fire. More than one case is reported in which a tank with tar and gravel roof on wood frame has been struck by lightning without causing a serious fire.

A common method of fire protection is the introduction at two or more places near the top of a tank of small pipe outlets, two inches or so in diameter, through which live steam may be discharged in case of fire, over the surface of the oil, for the purpose of smothering the flames. Chemical extinguisher and engine of the smothering type are also desirable and effec-

tive and should be on hand at convenient locations wherever oil is stored or delivered.

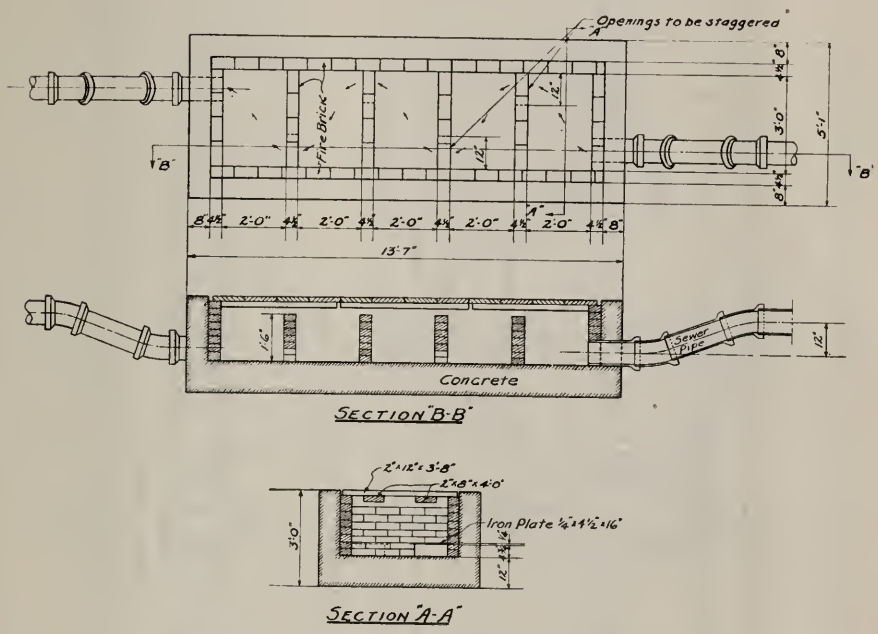
Oil Reclaiming Sumps

The use of sumps for reclaiming fuel oil from waste and runoff water around storage tanks and locomotive terminals is in general recommended only where required to prevent damage to adjoining property. Where the discharge into open drainage channels of waste water containing oil causes complaint, some means of separating the oil from the water and removing it before the water is turned loose becomes a necessity. With waste kept to a minimum as it should be the quantity of oil so recovered is not commonly great enough to make such recovery economical except as a means for preventing damage.

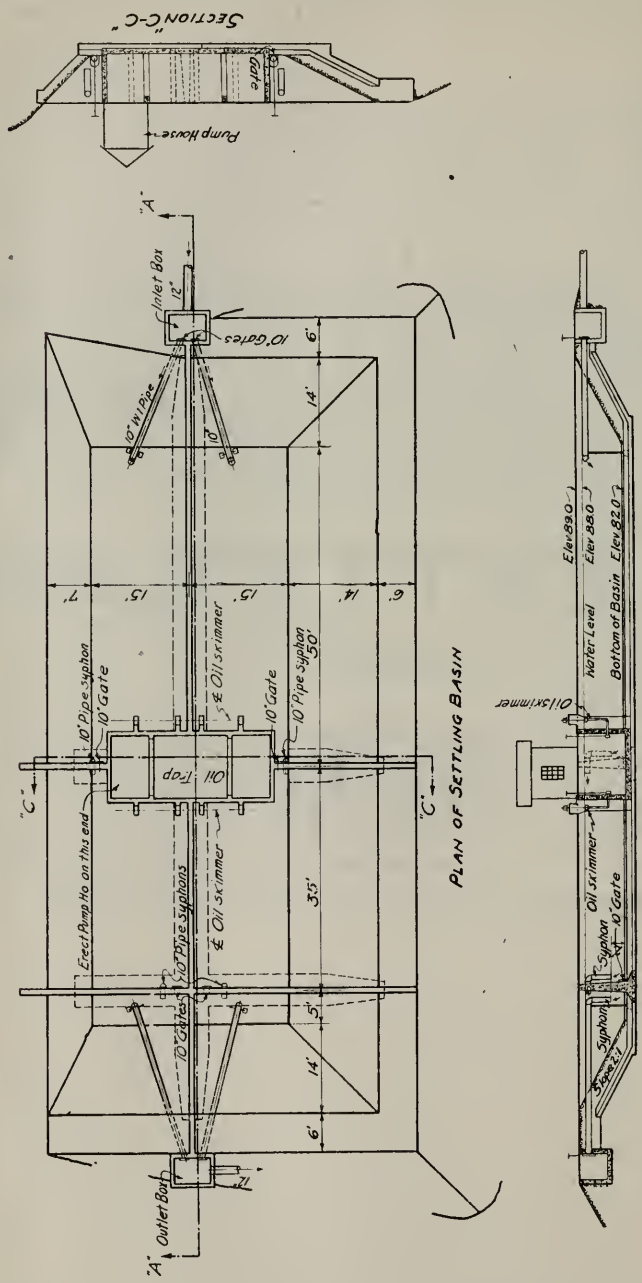
Sumps for separating oil from water operate by gravity, the lighter oil naturally rising to the surface when allowed to settle, while the water is drawn off from the bottom. A box with a series of baffles open at the bottom for the passage of the water is a common form, the oil being skimmed off at the top. Several plans illustrating such sumps, of various sizes, are appended. The capacity required depends largely upon the extent to which local conditions make necessary the complete removal of oil from the water. For the ordinary case the simple form of baffled box may be sufficient. For such conditions, one railway reports satisfactory results from a provision of 12 inches of width of baffle for each 20 gallons per minute of discharge.

The more elaborate design illustrated by the Santa Fe installation at Prescott was to meet a situation where use of water for irrigation purposes made necessary more complete separation. For such conditions, a formula is suggested for determining capacity which provides 10 square feet of top area and 25 cubic feet of volume for each engine handled per month.

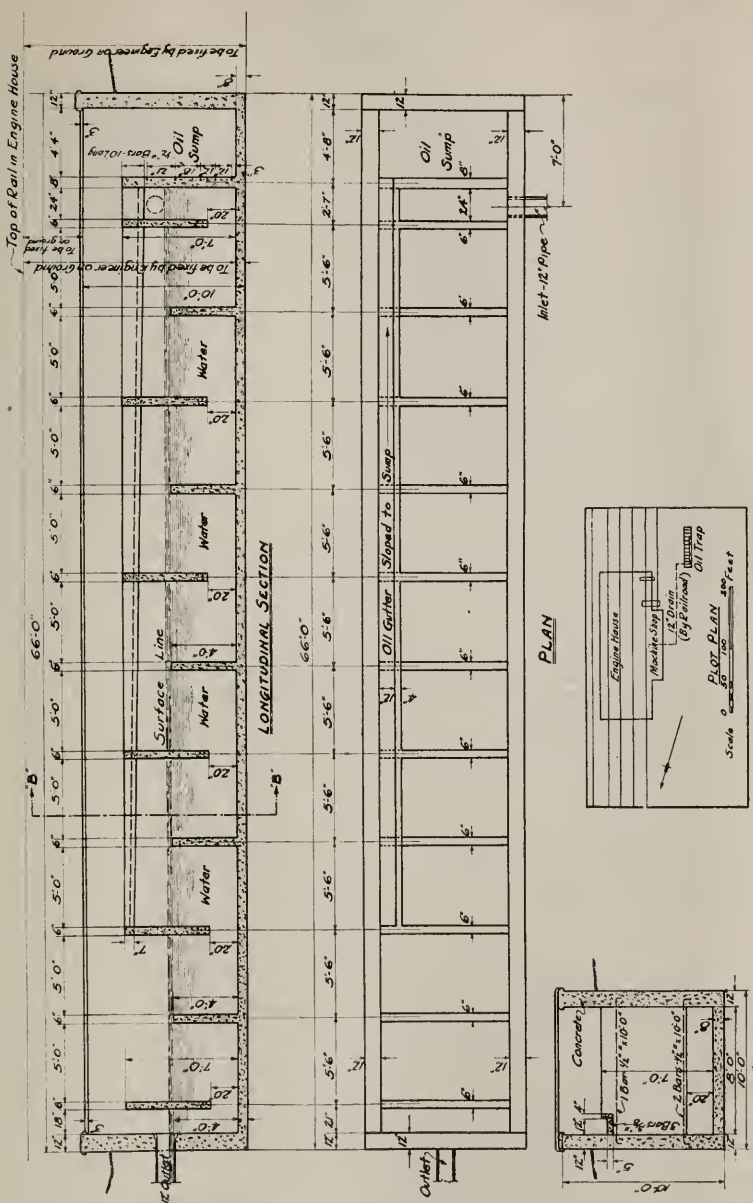
Some difficulty is likely to be experienced with filling of sump with sand and trash. For smaller installations it is customary to clean the sump at intervals by shoveling. At larger plants the accumulated rubbish may be pumped out by centrifugal pump.



Oil Sewer Trap—Chicago, Milwaukee & St. Paul Railway.



Oil Settling Basins—Atchison, Topeka & Santa Fe Railway Company (Coast Lines), Prescott, Ariz.



Oil Trap—Southern Pacific Company, Mojave, California.

REPORT OF COMMITTEE XIV—YARDS AND TERMINALS

J. E. Armstrong, *Chairman;*
J. R. W. Ambrose,
Irving Anderson,
C. E. Armstrong,
H. M. Bassett,
E. J. Beugler,
C. H. Blackman,
Alfred Bousfield,
C. A. Briggs,
H. F. Burch,
W. A. Christian,
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O. H. Frick,
E. H. Fritch,
Otto Gersbach,
John V. Hanna,
M. J. J. Harrison,
E. M. Hastings,
H. O. Hem,
J. G. Wishart, *Vice-Chairman;*
H. C. James, Jr.
D. B. Johnston,
H. D. Jouett,
E. K. Lawrence,
L. L. Lyford,
C. P. McCausland,
A. Montzheimer,
C. H. Mottier,
H. L. Ripley,
H. M. Roeser,
W. B. Rudd,
H. R. Saunders,
J. E. Saunders,
V. I. Smart,
C. U. Smith,
C. H. Spencer,
E. E. R. Tratman,
J. L. Wilkes,

Committee.

To the American Railway Engineering Association:

Your Committee on Yards and Terminals submits the following reports:

(1) Revision of Manual (Appendix A).
(2) Passenger Sub-Terminals (Appendix B).
(3) Freight Terminals—Suggested Arrangement of Units and Description of Operations for a Generalized Type of Large Hump Classification Yard (Appendix C).
(4) The Proper Width of Driveways for Team Tracks and for Freight Houses (Appendix D).
(5) Scales (Appendix E).
(6) The Proper Requirements for Practical Design and Construction of Humps in Terminal Yards. Committee reports progress on this assignment.
(7) Outline of work for ensuing year.

Collaboration with Other Committees

Pursuant to instructions, your Committee on Yards and Terminals has collaborated with other committees as follows:

Buildings: Permissible Grades for Ramps in Railway Buildings. See Appendix A—Revision of Manual.

Signals and Interlocking: Automatic Train Control; no request for collaboration has been made to this Committee.

Water Service: Types of Hydrants for Coach Yard and General Service. Report by Water Service Committee is satisfactory to this Committee.

Electricity: Flood Lighting of Classification Yards and for Other Railroad Purposes; no request for collaboration has been made to this Committee.

Uniform General Contract Forms: Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project; this matter is being studied and will be continued during the coming year.

Economics of Railway Operation: Flat Switching versus Hump Method; this matter is being studied and will be continued during the coming year.

Action Recommended

(1) That the recommendations in Appendix A be approved.

(2) That the report on Passenger Sub-Terminals be received as information (Appendix B).

(3) That the report on Freight Terminals be received as information (Appendix C).

(4) That the conclusions in Appendix D on the Proper Width of Driveways for Team Tracks and for Freight Houses be approved and inserted in the Manual.

(5) That the conclusions in Appendix E in regard to Scales be approved for insertion in the Manual.

Recommendations for Future Work

(1) Revision of Manual.

(2) Continue the study of design and operation of passenger terminals, with particular reference to convenience and economy of operation of coach yards, collaborating with Committee XXIII—Shops and Locomotive Terminals, and Joint Committee on Railway Sanitation.

(3) Collaborate with Committee XX—Uniform General Contract Forms, on Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project.

(4) Continue the study of design and operation of freight terminals, with particular reference to (a) car-to-car transfer of through L.C.L. freight; (b) general handling of L.C.L. freight, collaborating with Committee XXI—Economics of Railway Operation.

(5) Continue the study of the proper requirements for practical design and construction of humps in terminal yards, collaborating with Committee XXI—Economics of Railway Operation.

(6) Continue study of and specifications for various types of scales used in railway service.

(7) Study and report on weight control of railway test weight cars.

(8) Outline of work for ensuing year.

Respectfully submitted,

The Committee on Yards and Terminals,

J. E. Armstrong, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. E. Armstrong, Chairman, Sub-Committee; E. H. Fritch, M. J. J. Harrison, L. L. Lyford, C. H. Mottier, H. L. Ripley, V. I. Smart, E. E. R. Tratman.

Your Committee submits the following revisions of the Manual, and recommends their approval:

PASSENGER TERMINALS

Present Form	*Proposed Form*
(30) The gradient for passenger ramps should not exceed 10 per cent, etc.	(30) The gradient for passenger ramps preferably should not exceed 10 per cent, etc.
(40) A gradient of 6.5 per cent is the steepest yet used to any extent for trucking ramps in large passenger stations.	(40) A gradient of 7 per cent is the steepest yet used to any extent for trucking ramps.

SCALES

Your Committee calls attention to the fact that, during the past year, question has been raised as to the advisability of continuing the use of the three-second minimum weighing time which has heretofore been shown generally in those sections of the Manual relating to motion weighing of cars. Reasonable doubt has been cast on the sufficiency of this interval, in view of the increase in the average gross weight of loaded cars since the three-second interval was first accepted. Investigation and consideration of the matter by your Committee has resulted in increased doubt as to the adequacy of the three-second interval as an absolute minimum. In addition, cognizance has been taken of the concerted efforts now being made to reduce both the number and the money value of freight claims. Since better control of point of origin weights is an important factor in reducing freight claims, and as it is indisputable that an increased minimum weighing time, within reasonable limits, is productive of more accurate weights, your Committee feels justified in recommending an increase in the minimum time interval. It is therefore recommended that, in all parts of the Manual where reference is now made to a three-second minimum weighing time, the value be changed to four seconds.

Conclusion

1. When cars are to be weighed in motion, each car shall be entirely and alone on the scale a minimum of four seconds.

Appendix B

(2) PASSENGER TERMINALS

(a) Joint Passenger Terminal Agreement
(b) Sub-Terminals—Motor Bus

H. L. Ripley, Chairman, Sub-Committee; J. E. Armstrong, J. G. Wishart, J. R. W. Ambrose, H. M. Bassett, E. J. Beugler, C. H. Blackman, H. F. Burch, C. H. Crawford, E. H. Fritch, John V. Hanna, E. M. Hastings, H. D. Jouett, C. H. Mottier, W. B. Rudd, J. E. Saunders, V. I. Smart, C. U. Smith, C. H. Spencer, J. L. Wilkes.

JOINT PASSENGER TERMINAL AGREEMENT

At the annual meeting of the Association in March, 1927, the Yards and Terminals Committee submitted a comprehensive outline of "Points to be covered in an Agreement between Companies Participating in a Joint Terminal Project," stating the principles that should control in connection with each point.

The Association accepted the report of the Committee and the principles enumerated as being a synopsis of the cardinal points which should be covered in such agreement, and directed that the matter be referred to Committee XX—Uniform General Contract Forms, to prepare an "Agreement" in accordance with the principles therein set forth, in due form to be presented to the Association, co-operating with Committee XIV in connection with the matter.

Through some oversight the assignment to Committee XX was not made until into the summer and the Chairman of the Sub-Committee having the matter in hand for that Committee has advised the Chairman of this Sub-Committee that a draft is being prepared under the title of "Form of Agreement for Joint Ownership, Use and Management of a Terminal Project," but it will not be ready to submit, and Committee XX will not be prepared to present other than a progress report this year. It is recommended, therefore, that the subject be continued for the ensuing year as an assignment to Committee XIV, to co-operate with Committee XX.

SUB-TERMINALS
CO-ORDINATION OF STEAM RAILWAY AND MOTOR BUS TRANSPORTATION TERMINAL FACILITIES

A comprehensive survey, made as of July 1 and reported in Railway Age of September 24, 1927, shows 52 railways operating more than 800 motor buses transporting passengers over the highways. Of these 52 railways one-half are Class 1 carriers. On 44 of the 52 railways these buses are being used in line service similar to main or branch line rail service. Two-thirds of them are supplementing or extending train service and the balance have replaced discontinued train service. In all these cases, subject only to the divergence of the highway from the railway

the territories served by the motor buses are the same as that now or formerly served by railway trains.

While the growth of the motor bus as a means of passenger transportation has covered about ten years, substantially all the activity of steam railways in this field of passenger transportation has taken place within the last two years.

The question of terminals caused little difficulty at first, as the highways of the cities and towns seemed to furnish ample opportunity to stand, load, and unload buses. In many cases the nearest approach to a terminal, in the railway sense, consisted in hiring a vacant store, usually in the center of a chosen district, and fitting it up as a waiting room, with some sort of toilet facilities and sometimes separate facilities for handling baggage. It was often chosen regardless of its relation to, or distance from, the railway station with which the highway service was,

South Braintree, Mass.

in theory at least, to be co-ordinated. There were, of course, many exceptions to this method but generally speaking all of those exceptions arose in cases where the steam railway had available, and centrally located, a considerable area of railway-owned property adjacent to the passenger station. In the beginning, and continuing to the present time, such areas are still being used.

To illustrate this condition, a photograph is appended showing the station of the New York, New Haven & Hartford Railroad Company at South Braintree, Mass. The picture shows parallel tracks and shelter sheds. On one track stands a motor driven passenger coach. On the parallel track, adjacent to the station, stands a steam train from Boston. Across the platform, stands a motor bus which belongs to the New England Transportation Company, the subsidiary of the New York, New Haven & Hartford Railroad handling its highway service. This motor

bus, which provides a substitute for certain former branch line service, stands in the railway yard on the highway side of the platform awning. To complete the transfer from train to motor bus and the reverse, merely requires the passenger to step out of one conveyance, cross the narrow platform under shelter and enter the other. Where connections are made with definite trains at definite hours this arrangement works out reasonably well, and, so far as the passenger is concerned, requires no additional station or sub-terminal facilities, but in extreme cold or in storm it provides no place for the waiting bus to be kept out of the weather, and offers the further objection of some exposure of the passengers while transferring from rail to bus, as would be the case if they took a taxi.

With the growth of motor traffic, large cities in particular, seeing tremendous prospective congestion, have enacted ordinances forbidding motor buses to use the highway for the purpose of terminal waits. This action, actual or contemplated, has forced the immediate consideration of the problem of sub-terminals co-ordinated with the main passenger terminal, or as an extension service to pick up and deliver passengers nearer to the center of travel, a notable example of the latter being the Baltimore and Ohio service in New York City.

One of the first cities to forbid the use of streets for a terminal service was Worcester, Mass. The Worcester passenger station is used jointly by the Boston & Albany, the Boston & Maine and the New Haven and is quite centrally located. Grades in Worcester were separated several years ago, so the main tracks and the station proper are above the street level. There is a considerable covered space at the street level reached by stairs from the station and platforms, which space at the time the grades were separated, was used as a sub-terminal for street cars. With the coming of the automobile, street car service at the station was reduced sufficiently so that the street railway was able to release two of its tracks under the viaduct. Availing itself of this situation, and complying with the mandate of the Worcester Licensing Board that motor buses be kept off the highway while loading and discharging passengers, the New England Transportation Company made an arrangement with the three railways that operate the station and built an office and waiting room under the viaduct connecting by the stairway with the station and platforms at train level. From its location, the waiting room and loading platform is free from serious weather inconvenience, and the waiting room is heated. The motor buses are free to stand in the sheltered space so provided for such time as is necessary, and the co-ordination of terminals as between steam trains, street cars, and buses, in this instance, works out extremely well.

At the meeting of the Society of Terminal Engineers in New York, held January 11th, 1927, the extension of the Baltimore and Ohio service between Jersey City and New York was described at length. There again the railway terminal on the New Jersey side was used and, by giving up a pair of tracks and converting them into a driveway, they are

able to run the motor bus directly to the train, offering protection from the weather and the greatest of convenience to the passengers.

Several cities have enacted ordinances taking the motor bus terminal stops off the streets, and the solution of the problem so presented is as yet in the temporary stage. Waiting rooms located in business buildings are still in use and, for the time being, buses draw up to the curb, remain only long enough to load and unload, and proceed. Between times they are parked somewhere off the highway, using such available areas as exist in or about the neighborhood.

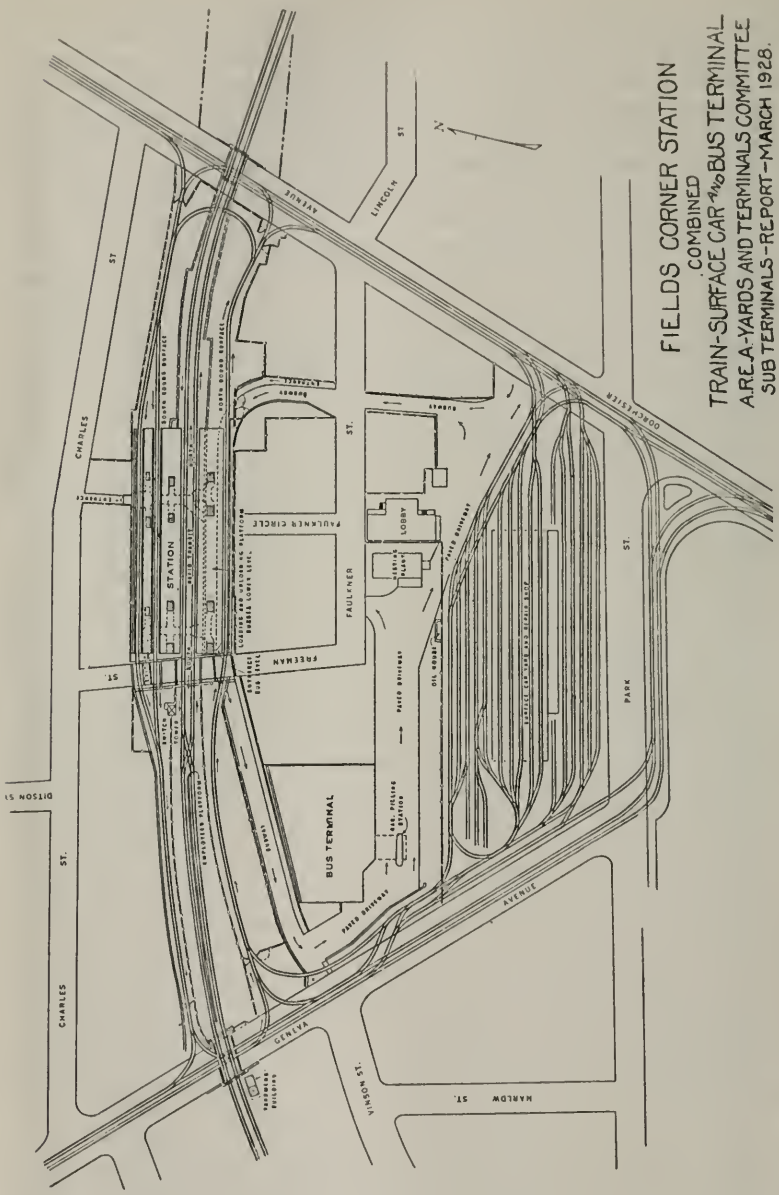
Elaborate designs for motor bus terminals are in process of development by highway transportation engineers. However, they demand large sums of money for their execution and some very elaborate planning in order to carry out the necessary financing. Ultimately, however, there can be little doubt that specially constructed buildings and accessories will be erected as sub-terminals, not only in New York but in other large cities, to meet the necessity for getting the motor buses off the streets and into privately controlled areas.

Examples of the modern idea in motor bus terminals are to be found in California and in Chicago, where the independent operators have gone extensively into the consideration of such buildings and their accessories. They are, however, entirely independent of any other form of transportation and so do not enter into the problem of railway sub-terminals. They can be studied, however, as a basis for ideas when the railways themselves are compelled to combine or extend their rail and highway passenger terminal accommodations.

A most excellent example of the way in which sub-terminals for the handling of highway passengers can be co-ordinated with railway stations is being displayed to-day by the work of the Boston Elevated System in the city of Boston. There is being completed in Boston an electrification for rapid transit purposes of the "Mattapan Branch," a line formerly operated by the New Haven Railroad in steam service. The right-of-way, with main tracks above the street grade, is being utilized by the rapid transit system, as are the stations formerly used by the steam road. All these stations are in the older residential portions of the city where the streets as a rule are narrow and accommodations for motor buses would be unsatisfactory.

An outstanding example on this branch of a co-ordinated terminal between railway, street car, and bus service is now under construction at Fields Corner, Boston, through the conversion of one of the stations on this Mattapan Branch. While the line will no longer be operated by steam trains, that point is not essential. It is a main station on a rapid transit line, formerly a steam line, and the principle is no different.

Using the location of the former railway station as a nucleus about which to work, an effective passenger transfer has been constructed. The main station is on the upper level, as are the two main tracks. High platforms serve these two main tracks. On this same level the street cars come in on one side, pass down an incline, through an underpass



FIELDS CORNER STATION
COMBINED
TRAIN-SURFACE CAR AND BUS TERMINAL
A.R.E.A.-YARDS AND TERMINALS COMMITTEE
SUB TERMINALS-REPORT-MARCH 1928.

Bus level Fields Corner Station looking towards Freeman St.

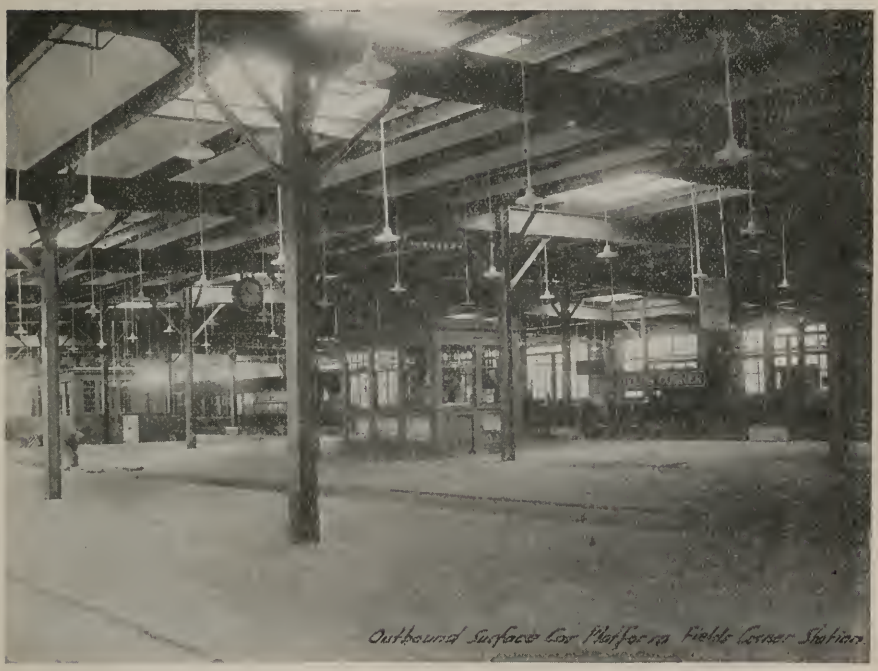
Entrance to Bus level Fields Corner Station from Faulkner St.

Geneva Ave.
Site for Bus Garage
Private way for Buses
Looking West towards Geneva Ave. from Fields Corner Station

East End Fields Corner

under the main tracks, and up an incline to the other side, making a loop circuit for the street cars, with loading platforms between the main line tracks and the street car tracks. The loop connects at either end with the trolley tracks in the streets.

Under the main station, and level with the streets in the neighborhood, is located the enclosed driveway for the buses, wide enough to pass one bus by another. A wide concrete platform is provided along the inner edge of the driveway. This platform connects near either end of the station with a corridor and easy stairways connect with the loading platforms above. Platforms open out at either end on to an existing highway.



Outbound Surface Car Platform Fields Corner Station

As in Worcester, this passenger terminal is provided with waiting rooms, toilets, booths for concessionnaires, lobbies for employees, etc., but here they are on the main track level, and serve three distinct classes of passengers—the main line traveler, the traveler by surface trolley cars and the traveler by motor bus. It provides a safe and convenient means of transfer from one to the other, all protected from the weather, and yet without costly construction. Any steam railway station, where the main line and the street crossings are at separate grades, could be adapted as a sub-terminal to take care of motor bus or trolley car business in a similar manner.

While it is true that all motor bus terminals are not located in cities the size of New York, Boston or Worcester, nevertheless the methods used in overcoming the problem of congestion in the cases of Boston, Worcester and Jersey City, as cited, furnish a basis upon which similar situations in lesser communities may be met.

Generally speaking, the problem of co-ordinated rail and highway terminals is one that has but recently been forced upon the attention of the railways, even those roads which operate both types of transportation. Except in the case of new construction it is bound to be a problem which will cause more or less annoyance, unless, as was the case in Worcester, the existing structure readily lends itself to a co-ordination plan.

There is, of course, one feature of co-ordination which may be expected to cause some embarrassment. Railway stations, generally speaking, and particularly in the lesser cities, are not located in the sections from which motor bus travel originates. The problem in that case is one of physical connection or extension of service between existing railway stations and a more convenient sub-terminal for the highway transportation. That was the problem that faced the Baltimore and Ohio in New York. It is complicated by the obvious necessity of the highway unit discharging its principal function of providing accommodations; that is to say, going where the people are who desire to use it, rather than attempting to force the people to inconvenience themselves because of remote location. Any physical problem involved in the situation must be solved in the interest of convenience to the passenger, rather than that of convenience to the transportation interests.

In solving the problem of co-ordinated terminals, the flexibility of the newer method of transportation and the accessibility of terminal service, must not be sacrificed, or the investment of the 52 steam roads in the great fleet of motor buses may prove disappointing.

While the illustrations that have been used in this report are in the east, the situation which they typify, and the necessity for serious and early attention to the problem, is common to all parts of the country, the difference being only one of degree and not at all one of principle.

This report is presented as a matter of information only. No conclusions are drawn and no specific recommendations are included. It is recommended that the subject of sub-terminals be discontinued for the time being.

Appendix C

(3) SUGGESTED ARRANGEMENT OF UNITS AND DESCRIPTION OF OPERATIONS FOR A GENERALIZED TYPE OF LARGE HUMP CLASSIFICATION YARD

L. L. Lyford, Chairman, Sub-Committee; J. R. W. Ambrose, C. E. Armstrong, J. E. Armstrong, H. F. Burch, W. A. Christian, C. H. Crawford, O. H. Frick, Otto Gersbach, J. V. Hanna, E. M. Hastings, H. C. James, Jr., D. B. Johnston, H. D. Jouett, E. K. Lawrence, C. P. McCausland, A. Montzheimer, W. B. Rudd, J. E. Saunders, H. R. Saunders, C. U. Smith, J. G. Wishart.

In the 1927 Proceedings, Volume 28, are found the conclusions of the Yards and Terminals Committee that should govern the design of freight terminals. A yard designed with these features in mind should produce a freight terminal that can be operated at the least cost. This year's report of the Sub-Committee applies these principles to the design of a large hump classification yard, shown in Exhibit No. 1.

It is comparatively simple to lay out a typical yard plan without having in mind any particular location, but when this plan is applied to a particular location there are always certain restrictions as to property and other local conditions, and the Engineer consequently may not have the opportunity nor liberty to develop what, theoretically, would be the most economical layout.

In the study that is submitted, no consideration has been given to the amount of property available nor the topography of the country. Probably there are facilities included in this general type of yard that seldom, if ever, would all be needed in one yard, in actual practice. The different units that go to make up a completed yard would vary with different railways, with different kinds of traffic and with different conditions surrounding the handling of that traffic, so that in this study only general principles of design are being considered.

The northward main track is shown as passing by one side of the yard and the southward main track the opposite side. In practice, it is often desirable or necessary to have both main tracks on the same side of the yard, making it necessary to provide one or more thoroughfare tracks on the opposite side.

In this plan an auxiliary running track, located between the two main tracks, extends south from the south end of the yard, and such a track should be at least as long as the longest train that is run on this particular district. It can also be used for warming up cars that have been standing in receiving yards, which is desirable in cold weather.

The northward receiving yard consists of 20 tracks of 110 car capacity each, holding a total of 2200 cars. If this yard is located at an intermediate terminal, many of the trains will terminate at the yard and it will not be necessary to make provisions for setting out part of the

trains in the yard, although it may be necessary to provide tracks for inspecting trains while changing locomotives or crews. If it is located near the end of a railway near a large city, it is probable that a number of manifest trains will handle dead freight into the yard and then continue on their way with their manifest loading to the city terminal. In that case, it is necessary either for the train to leave its manifest loading on the main track or on the auxiliary main, while the remainder of the train is being set out in the yard. Provision will have to be made on both sides of the receiving yard to get this locomotive back to the remainder of its train without interfering with the humping operations. There should be a sufficient number of tracks in the receiving yard so it will not be necessary to hold out trains on account of insufficient room. The capacity of such a classification yard is so great that it is probable, during certain periods of the year, it will not be necessary to operate all of the shifts. Therefore, there will have to be sufficient surplus capacity to receive the trains arriving during that period when the hump is not operating.

In previous reports, the Committee has set out a minimum number of tracks which should be sufficient to accommodate the number of trains arriving during a certain specified period. At one of the important yards of this kind, experience seems to indicate that the number of tracks should approximate 50 per cent of the number of trains entering the yard in a 24 hour period. Often the receipts during a three or four hour period will approximate 50 per cent of the number of trains entering in a 24 hour period. The distance from the end of the receiving yard to the hump should be such as not to obtain an excessive gradient and to provide the necessary number of crossovers between the end of the yard and the hump, assuming there will be two tracks over the hump. There should be at least two crossovers in this territory in opposite directions.

The northward classification yard as proposed consists of six units of ten tracks each, or a total of 60 classification tracks holding 5000 cars. These tracks vary in capacity from 60 to 100 cars. In actual practice, this would depend upon the number of classifications it is necessary to make at the terminal and how fast these classifications build up. For instance, there may be a heavy run of business to certain connecting lines, making it necessary to handle three or four transfers every 24 hours. In such cases, provision should be made for long tracks, as this avoids doubling over to build up a train. In cases where the transfer or road train consists of groups of cars to be delivered to many different locations, short tracks are satisfactory because it will be necessary to build up a train from a number of different classification tracks. One of the reasons for providing a few long tracks in the classification yard is the possibility of running trains directly from the classification yard. There are reasons both for and against such a practice. If trains are run directly from the classification yard it is necessary to have a second or a third track for this same classification, in order to take care of the overflow when the track is filled. It is not possible to immediately run a

train when the track becomes full, as it has to be coupled up, inspected, tested for air, etc. On the other hand, moving this cut of cars to a departure yard costs considerable and consumes yard-engine hours doing work that could just as well be performed by road engines.

There are provided in this classification yard three short tracks to receive bad-order cars. In some instances, it might be possible to set aside one of these tracks for light repairs and have this work done in this location, but to do this a second track must be set aside for use while light repairs are being made, as repairmen cannot work on a track while cars are being humped to it.

There is provision made on one side of this classification yard for eight tracks for hold cars, such as grain held for inspection and coal held for billing. These cars, during certain periods, may number from 500 to 1000 and some provision must be made to store them in such a manner that they are easily switched. As releases are obtained for these cars two or three times daily, they are in a position to be humped and forwarded to destination. Provision is made for handling these cars back for rehumping without taking them back over the hump.

A series of crossovers is run through the easterly ten classification tracks, so that these tracks can also be used for hold cars in case the hold yard is full. Cars from these tracks are pulled back over the auxiliary track immediately west of the main line into the most easterly receiving yard track and are then in a position to be put back over the hump. The moving of these cars from the hold track can be carried out without delay to hump operation, as cars destined for these classification tracks can ordinarily be routed temporarily to some other track while the move is being made. There is also the advantage of getting a better gradient, as in the winter it may take from two to three locomotives to get hold cars back over the hump that can be handled the other route with the one hump-engine.

At the north end of the classification yard an independent ladder and drill track is provided for each ten track unit. As a rule, not more than three tracks can be provided for the movements between the classification and departure yards, and under ordinary conditions it would not appear practical to provide independent leads to the end of each of these ten track units. While there are at times some advantages, there are also disadvantages, particularly if trains must be built up from classifications out of several different ten track units. Provision is made for handling bad-order cars direct from the three tracks in the classification yard to the car repair yard without moving through the throat between the classification and departure yard.

The departure yard has eight tracks of 110 cars capacity each, or a total of 880 cars. While in theory probably as many tracks should be provided in the departure yard as in the receiving yard, this may in practice be reduced if there is an opportunity to properly space the departing trains. It can be reduced also, if it is possible to run some of these trains direct from the classification yard. Experience indicates that it takes more engine-hours to couple cars and build up trains in the departure yard

than it takes in hump-engine hours in classifying. The cost of classifying cars, by means of hump classification yards, has been reduced, but the cost of subsequently assembling the cars into trains is considerable, and running trains directly out of the classification yard (thus doing away with pull-down engines) should result in more economical yard operation.

At the north end of the departure yard is an auxiliary main track which should be of such length as to enable a train to get out of the yard and on to the main line without delaying other trains, or unduly delaying yard operation. This track can also be used by hump-engines in warming up cars that have been standing in the receiving yard, which is desirable in cold weather.

At the north end, on the inside of the northward classification yard, provision is made for eight short tracks for the storage of company fuel. It is the intention that company fuel should be moved directly from classfication yard tracks into these hold tracks, where they are in such a position that they can be moved readily to the fuel unloading tracks in the locomotive terminal. If fuel is received from the opposite direction, this yard would be correspondingly located.

Immediately west of the northward departure yard is a hold yard of five tracks for 150 cars. Here cars humped from the south and destined to points in the same direction would be held until they could be sent back over the southward hump. In certain yard locations, this is necessary as business from branch lines comes in at one end of the yard and departs at the same end, making it necessary to move these cars over both humps. This short yard is provided in lieu of handling the cars from the northward classification yard immediately to the southward receiving yard.

There is also provided an L.C.L. hold yard of five tracks for 150 cars, to hold this type of freight until it can be moved to the main L.C.L. yard for rehandling of the packages and loading for destination. Undoubtedly, in many freight terminals, provision will not be made for handling L.C.L. shipments, in which case such a storage yard would not be necessary.

Between the northward departure yard and the southward receiving yard provision is made for a car repair yard, with its auxiliary buildings. The yard consists of 22 tracks holding 880 cars when spaced 55 feet per car, and is so located that bad-order cars in the classification yard can be easily switched to and from the yard at either end.

At the north end, provision is made for a sorting yard of 380 cars, which will serve as an overflow and the storing of cars that cannot be immediately repaired. In the operation of a repair yard, it is often necessary to give preference to a certain class of equipment, and there must be provision for sorting this particular equipment and storing the remainder until opportunity is obtained for repairing them. This applies only to empty cars, as loads are moved direct to the repair tracks.

At the north end of the classification yard provision is made for four caboose tracks, which would be of such length as to hold the required number of cabooses. The method of operation would be to take these

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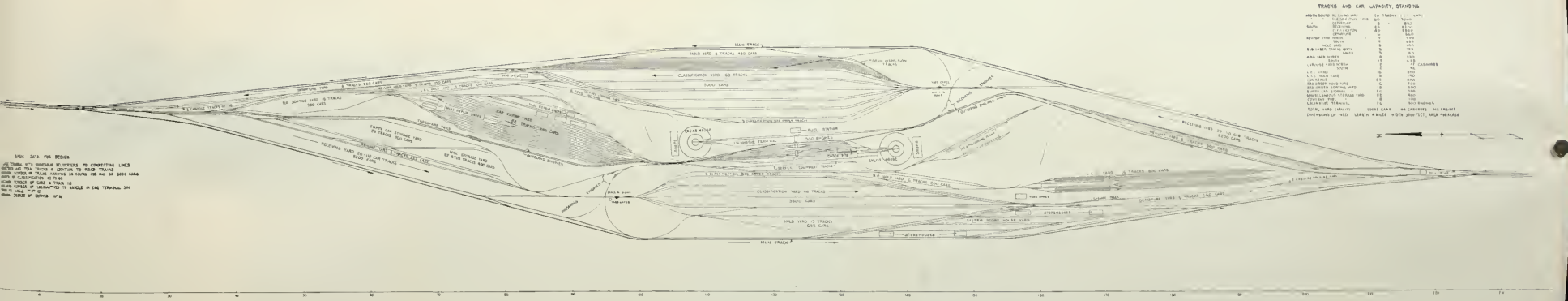

Generalized Type Hump Classification Yard
Scale 1 inch = 800 feet

cabooses off the rear end of trains arriving in the southward yard and store them on the caboose tracks until they are needed for northward departing trains. They are then taken from the yard by the pull-down engines and placed on the rear of the train in the departure track.

The southward portion of the yard will, in general, consist of the same number and type of units, the plan providing for an ultimate capacity of 20 tracks in the southward receiving yard of 110 cars capacity each. On the inside of this yard, provision is made for a small rehump hold yard to place cars received over the northward hump and destined for points requiring cars to move over the southward hump. In addition, there are storage tracks for miscellaneous empty equipment when not in use. This yard should be so located that it will be available for the most economical handling of cars, depending upon the direction of receipt and departure of a preponderant number of cars. What is said about the distance from the end of the receiving yard to the hump on the northward yard applies equally to the southward yard. It is probable there will be a preponderance of loaded cars in one direction and a preponderance of empty cars in the opposite direction which might affect, to some extent, the gradients that would be used off the two humps.

The southward classification yard consists of four ten track units, a total of 40, with hold tracks and bad-order tracks on either side. Cars can be moved back from the hold tracks to the receiving tracks without passing over or interfering with the operation of the hump.

At the south end of the classification yard are tracks for holding bad-order cars, from which the cars can be handled direct to the repair yard. A connection between the south end of the southward classification yard and the north end of the northward receiving yard provides for handling cars received from the north and destined to points north. A rehumper yard of five tracks with 300 car total capacity is provided for these cars. Each ten track unit in the southward classification yard is provided with an independent drill track.

The throat between the southward classification and southward departure yard is composed of three tracks, so that three movements between these yards to certain tracks can be made at one time. This is desirable in a classification yard, because there will be certain periods when manifest trains are leaving, when it will be necessary to work from three to five engine-crews at one time in the pull-down service.

As in the northward yard, provision is made for a departure yard of six tracks of a total capacity of 660 cars. The number of tracks in the departure yard will depend upon the number of trains it will be necessary to run from this yard and the schedule of these trains. If certain business can be run direct from the classification yard, the number of engine-hours worked in the yard will be at a minimum.

A caboose yard at the south end of the departure yard has a sufficient number of tracks to hold the cabooses required in the service. A single caboose track near the north end of the departure yard will save time of engines in getting caboose on trains, as they can bring several back in making trips to the south end.

In the southward unit provision is made for System storehouses and store yard tracks to serve. It is not always possible to incorporate a unit of this kind close to this type of yard, but where it is possible a considerable saving can be made as inbound cars can be moved direct from the classification yard to the store tracks and outbound cars handled over the hump with a minimum number of engine-hours. Where these facilities are located independently of the yard, it will be necessary daily to operate a train from the yard to the location of the System storehouse and the location adjacent to a yard eliminates this switching or road movement.

The plan includes also an L. C. L. yard with platforms and sheds and 16 tracks, for making up and consolidating L.C.L. shipments that otherwise might have to be handled at the in and outbound freight houses. Sometimes the volume of local business at these houses is so great it is not desirable to add the business originating at other terminals, destined to points beyond or to connecting lines. Where freight houses are of great length it costs considerable to move the package from end to end, and at large terminals a point is reached where it is not advisable to handle other than local business through these freight houses. Furthermore, the cost of switching in congested territory of this nature is greater than the cost of switching cars in a classification yard to the L.C.L. yard. The necessity for a yard of this kind in a hump yard layout would probably not occur often.

The locomotive terminal is shown located between the two classification yards, resulting in a minimum amount of handling and of distance traveled by road and switch engines operating into and out of the yard.

The plan provides for duplicate units of enginehouses, cinder pits and engine-storage tracks, all located for the greatest economy of space. Objection might be made to this arrangement on account of the possibility of requiring two sets of supervisory forces for the two enginehouses. In the development of a yard of this size it is probable that in the beginning one enginehouse with coaling station and cinder pits and tracks to serve would be adequate, but as the volume of business increased, it would be desirable eventually to provide a second unit. An objection to the location of the enginehouses in this vicinity is the fact that with the wind in certain directions, the smoke from the enginehouse might drift over to the humps, causing poor visibility and thus interfering with hump operation. If the smoke would prevent safe and continuous operation of the humps then the locomotive terminal should be located at a more distant point. Such a location, however, will result in increased operating costs, as it will take locomotives longer to move from the locomotive terminal to the more distant points in the yard. Provision is made that running tracks or thoroughfare tracks be kept open for handling locomotives to either end of the yard and to the humps. As a rule, crews on the yard-engines will take their assignments at the yardmasters' offices at the humps and at each end of the yard. Double track movements are provided for the movement of locomotives from locomo-

tive terminal to each end of the yard, which eliminates the necessity of providing switch tenders. A track runs under each hump, converging into and connecting with the outside thoroughfare track of the yard, forming wye tracks on which locomotives can be turned in emergencies.

Icing tracks and facilities are provided south of the south enginehouse and connecting with the southward classification yard and the northward receiving yard. The location of this icing plant will depend, to a great extent, upon the direction in which the cars to be iced are moving. The preponderant number of cars to be iced is always in one direction, and the icing facilities should be located so as to make it most economical to ice cars moving in that direction. It will always be necessary to ice a lesser number of cars in the opposite direction, and before the location is definitely approved, consideration should be given to the cost of getting these cars to the icehouse.

In some yard locations it will be necessary to provide tracks and other facilities to feed and water cattle, hogs and other livestock. The facilities will consist of stockpens and feeding lots served by one or more unloading tracks adjacent to stockpen chutes, as well as a track to handle feed to storage warehouses. If the requirements of the service are such as to require extensive facilities, it will be necessary to have storage tracks for stock cars, as well as unloading tracks adjacent to the stock chutes.

While the service performed is different than in ordinary yard classification, yet the location of these facilities adjacent to a terminal yard is desirable, in that it will be possible to handle the cars for unloading by a yard crew instead of the crew of a road train. The location of these facilities in the yard should be such as to have them accessible to the main line and permit trains to arrive and depart with the least amount of extra movement and delay.

With the development of car retarders it is probable that when the volume of business is such as to justify hump yards, this type of retardation will be used rather than car riders. Previous reports of this Committee have dealt with the question of gradients and the arrangement of tracks to permit the use of this device. The smaller number of car retarder units it is necessary to provide, the less volume of business it will take to justify the construction of hump yards, and undoubtedly plans will be developed for track arrangements that will permit one retarder unit to serve a greater number of tracks than heretofore. The majority of the present retarder installations are so arranged that the operator handles both the switches and the retarders within a specified group; thus the control of the car is entirely in the hands of that one man. For this system of operation it is very necessary that the operator should be able to see the car from the time it enters his territory until it passes over the last retarder and out of his control.

A system of flood-lights is essential and should be so located and focused that the greatest amount of illumination is provided where most needed.

Water columns are located at the throat of the yards and at the ends, where locomotives can take water without interfering with the arriving or departing trains.

Unless modern facilities for handling waybills are provided in a yard of this magnitude, there is expense and delay in handling bills to the general yard office and getting them out as the train leaves the yard. At a recently constructed yard, the waybills are handled to the general yard office and to the yard office at the departing end of the yard by underground pneumatic tubes. On arrival of trains in the receiving yard, the conductor gives the waybills and a consist of his train, in car order, to the yard clerk who immediately sends them through the pneumatic tube to the general yard office. There the waybills are checked, destination of car corrected or changed on instructions from the shipper, and a switching list of train immediately prepared. This list is sent to the hump yard foreman and to the various retarder tower operators by means of the teletype machines.

The master teletype machine is operated from the yard agent's office and in each tower there is printed a switching list containing the following information:

Location in the cut, numbering from the head end.
Car number and initials.
Contents.
Destination of the car by station or railway.
Number of track to which it goes in the classification yard.
Heavy or light load.

With this arrangement there is no delay in getting the switching list prepared, so that as soon as the train has been inspected, it is ready for humping and only one man has been employed (the teletype operator) in the transmission of this information. When the cars are assembled in trains in the departure yard, the yard clerk furnishes a consist of the train, waybills are assembled and immediately sent by pneumatic tube to the yardmasters' office at the departing end. This handling not only enables the speeding up of all the operations in the yard, but does away with expensive messenger service and consequent delay.

In addition to a general yard office with working facilities for a maximum of 50 to 75 clerks and supervisory forces during any one shift, provision should also be made for yardmasters' offices between the north and southward units at each end of the yard, at each end of the classification yard and on each hump, a total of six. The size of these yard offices will depend upon the work to be done; the largest offices usually being at the ends of the yard, as it is at these points that the largest number of trainmen receive their assignment for their day's work.

Air testing plants should be provided at each departure yard, and air lines run across the tracks so that as soon as trains are pulled down, the air equipment can be tested and the train line built up to the proper pressure before the arrival of the locomotive. In case trains are run

direct from any tracks in the classification yards, air lines should be extended to these tracks for the same purpose.

For weighing cars uncoupled as they pass over the hump, a scale should be provided just below the apex of the hump, the gradients being laid in such a manner that immediately after uncoupling, the car will accelerate to such an extent that it will clear the car following and not pass over the scale too fast to be weighed. Track scales have been developed in recent years of capacity, type and length suitable for this purpose. Operation may be facilitated by installation of track scales of sufficient capacity to sustain, without any damage, the heaviest locomotives likely to be used in this yard, thus making dead rails unnecessary. The length of the scale should be so related to the gradients above and across it that an adequate minimum weighing time will be secured for free running cars. Scales suitable for this purpose will represent a substantial investment and they should be protected by supplying artificial heat in their pits during cold weather. This will also tend to insure continuity of service, in that it will prevent sweating, due to temperature changes, and corrosion of certain essential parts and variations in accuracy due to wide temperature changes. With this arrangement it is possible economically to weigh and check-weigh a great many cars which might not otherwise be weighed. The fact that it is possible to check-weigh these cars without increased expense gives the railway a check on the other weighing points, and has an inestimable influence on the general accuracy of weighing performed at other points on the railway.

Some provision should be made for varying the height of the hump during summer and winter, as a gradient that gives the proper speed for loads in summer is not adequate for loads in the winter. Provision should be made for a greater change between winter and summer conditions on one of the hump tracks, as empty cars in the winter need much more acceleration than can be obtained by a slight change in the gradient just below the hump apex. This is accomplished in yards with two hump tracks, by raising one of the tracks two or three feet above the elevation of the track on which loaded cars are humped.

The yard should be provided with adequate telephone service, so that information can be transmitted quickly to and from supervisory officers.

Conclusion

It is recommended that this report be accepted as information.

Appendix D

(4) THE PROPER WIDTH OF DRIVEWAYS FOR TEAM TRACKS AND FOR FREIGHT HOUSES

C. H. Mottier, Chairman, Sub-Committee; Irving Anderson, C. E. Armstrong, J. E. Armstrong, H. M. Bassett, E. J. Beugler, W. A. Christian, C. H. Crawford, O. H. Frick, Otto Gersbach, John V. Hanna, H. C. James, Jr., D. B. Johnston, H. D. Jouett, C. P. McCausland, A. Montzheimer, H. L. Ripley, H. R. Saunders, C. H. Spencer, E. E. R. Tratman, J. L. Wilkes, J. G. Wishart.

The increase in the length of motor trucks and their increased use in the handling of freight make this assignment of general interest to all railways. Many driveways built when the horse-drawn vehicle was the principal means of transporting freight to and from freight houses and team tracks have had their usefulness greatly impaired because their width is now inadequate for the proper accommodation of the large motor trucks using them.

The requirements for team-track driveways will first be considered, after which consideration will be given to the width of freight-house driveways.

TEAM-TRACK DRIVEWAYS

A team-track driveway may serve only one track, may be adjacent to a public street (thereby providing backing up space to the cars without blocking the street) or it may be located between and serve two tracks. Obviously the main problem relates to the last mentioned case, and therefore, this study will be based principally on that type of team track.

The Committee has pursued the following three lines of investigation in arriving at its conclusions:

(1) Existing driveways have been studied to determine the influences that should be given consideration in determining the desirable width of driveways.

(2) The trend in the use and length of motor trucks used in team tracks has been studied with a view of determining the probable future length of trucks that will use team-track driveways and for which the driveways should be designed.

(3) Information has been collected as to the present tendency among American railways in the design of team tracks.

These three investigations will be presented in the order given.

The Committee desired to study the relation between width of driveway, traffic, and vehicular delay. For this reason, an effort was made to locate team tracks with a relatively great density of traffic and with sufficiently narrow driveways to result in congestion and delay to vehicles. As several members of the Committee were located in Chicago it was decided to make a rather comprehensive study of all of the Chicago team tracks and most of the observations were made in the Chicago area.

Practically all of the Chicago team tracks were visited and 22 in 11 yards were selected as being the best suited for a study of this character. In all, 26 team tracks in 13 different yards were observed.

The Committee found difficulty in locating team tracks with sufficient density of traffic to result in a large amount of delay. There are many team-track driveways that are too narrow to be of value when both tracks are occupied. In most cases where such narrow driveways exist the practice is to place cars only on one track and in this way the team tracks are used to about 50 per cent of their original capacity. Relief has been obtained in many of the narrow driveways by introducing cross driveways and the relief obtained by this expedient has made many narrow driveways serviceable that otherwise could not have been used to advantage.

In order to place all of the observed team tracks on as nearly the same basis as possible, all periods of observation when the number of vehicles in the driveway did not equal 15 per cent of the number of cars served by the driveway for a continuous period of at least 24 minutes, were ignored. Pertinent information collected in the team-track observations appears in Table 1.

On the assumption that the delay to vehicles varies directly with the average number of trucks per car in the driveway and with the length of team track (number of cars served) all delays in vehicle minutes per hour were reduced to the common basis of the average traffic and the average number of cars served. The resulting calculated delays appear in Column 27.

The contention is not made that the above assumptions are precise. The number of observations is inadequate to prove any such relation where so many variables are involved. However, the general tendency of such a variation is obvious and the results obtained are indicative of the effect of driveway widths on delays. A very large number of observations would be necessary to establish a quantitative basis for delays, and the variables involved would make the basis of questionable value. The results obtained do illustrate certain facts, which readily become apparent when observing the action of vehicles in driveways, and these will now be presented.

For driveways less than 24 ft. in width the delays are very heavy. For driveways between 24 and 30 ft. in width the delays are considerable but do not vary directly with the width of driveways. For driveways over 30 ft. in width delays are infrequent.

The reason why the amount of delay does not vary directly with the driveway width, to a large extent, is due to the tendency in certain cases for drivers to adjust themselves to the width of the driveway, while at others they are less careful in this respect. The extent to which drivers skew vehicles was observed and is shown in Table 2. It will be noted that, speaking generally, there is a greater tendency for teamsters to skew their trucks against a car if the driveway is narrow. There are two reasons for this. One is that the driver prefers to leave his truck in such a position that he can move straight out with the load without having to seesaw with the loaded truck. The other is the disposition on the

part of many drivers to place their trucks in such a position as to permit other trucks to pass, irrespective of the width of the driveway. Table 2 shows that this disposition is not general and occurs in some driveways to a greater extent than in others.

There is a greater tendency for delays to occur in stub-ended than in open-ended driveways. This is due to the fact that with driveways open-ended, a teamster need not be limited to one entrance but can drive around and enter the driveway from the end free from blockade. This

TABLE 1 - OBSERVATIONS ON TRAFFIC & DELAYS IN TEAM TRACKS & THE RESULTING RELATIONS BETWEEN THE DELAYS & WIDTH OF DRIVEWAYS.

STUDY Nº	DRIVEWAY				TIME PERIOD HOURS	VEHICLES IN DRIVEWAY DURING TIME PERIOD (COLUMN 6)										VEHICLES CREATING DELAYS. VEHICLE - MINUTES					TOTAL DELAY IN DRIVEWAY VEHICLE - MINUTES	TOTAL TRAFFIC & DELAYS EQUALIZED ON BASES INDICATED - VEH MIN.				
						SHORT ◑ TRUCKS		1-HORSE WAGONS		2&3 HORSE WAGONS		LONG ◑ TRUCKS		ALL VEHICLES								ONE HOUR TIME PERIOD (COL. 6)		MEAN LENGTH OF TEAM TRACKS - TOTAL OF 33 CARS OR 1.5		
	WIDTH FEET	STUB ENDED	OPEN ENDED	TOTAL CARS ON TRACKS*		NUMBER	VEHICLE MINUTES	NUMBER	VEHICLE MINUTES	NUMBER	VEHICLE MINUTES	NUMBER	VEHICLE MINUTES	NUMBER	VEHICLE MINUTES	SHORT TRUCKS	1-HORSE WAGONS	2&3 HORSE WAGONS	LONG TRUCKS	ALL VEHICLES		TRAFFIC (COL. 16)	DELAYS IN DRIVEWAY (COL. 22)	TRAFFIC (COL. 23)	DELAYS IN DRIVEWAY (COL. 24)	DELAYS COL. 26 EQUALIZED FOR MEAN TRAFFIC FLOW 2&3 VEH. MIN. (COL. 25)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	15		X	20	0.58	3	74	-	-	-	-	1	6	4	80	31	-	-	-	31	31	138	53	228	87	162
2	20		X	42	0.63	1	21	2	58	-	-	4	85	7	164	-	19	-	6	25	25	260	39	204	31	65
3	22		X	42	0.40	-	-	3	55	4	72	4	71	11	198	-	16	17	-	33	33	495	83	389	65	71
4	22		X	33	0.45	-	-	4	72	2	54	2	49	8	175	-	21	-	15	36	54	389	120	389	120	132
5	24		X	44	1.27	3	137	1	45	1	76	11	336	16	594	-	-	-	40	40	53	468	42	351	31	38
6	24		X	46	0.93	4	88	-	-	-	-	14	325	18	413	-	-	-	16	16	20	444	22	318	16	21
7	24		X	39	1.17	5	224	-	-	1	56	8	231	14	511	-	-	-	8	8	8	437	7	370	6	7
8	27		X	43	2.88	3	92	-	-	1	26	48	1589	52	1707	-	-	-	68	68	184	592	64	455	49	46
9	27		X	40	2.25	-	-	-	-	-	-	25	933	25	933	-	-	-	20	20	26	415	12	342	10	12
▣10	28		X	66	5.35	-	-	2	104	34	1627	52	2173	88	3904	-	-	-	145	145	481	730	90	365	45	52
11	35		X	41	0.75	-	-	4	125	-	-	4	135	8	260	-	-	-	-	-	0	346	0	278	0	0
12	40		X	27	0.43	-	-	5	83	-	-	12	192	17	275	-	-	-	-	-	0	639	0	782	0	0
13	40		X	28	0.40	2	26	1	24	-	-	5	97	8	147	-	-	-	-	-	0	368	0	433	0	0
14	24	X		22	4.13	1	5	4	271	11	977	13	714	29	1967	-	-	-	110	110	248	477	60	716	90	54
15	24	X		24	2.47	1	56	3	125	12	812	3	185	19	1178	-	-	40	20	60	259	477	105	657	144	94
16	24	X		23	7.52	7	263	5	250	35	1750	16	584	63	2847	-	-	12	77	89	169	380	23	545	33	26
17	24	X		20	2.20	1	19	-	-	4	193	7	315	12	527	-	-	-	4	4	4	240	2	395	3	3
18	24	X		17	2.30	-	-	2	76	6	363	4	143	12	582	-	-	3	8	11	11	253	5	491	10	9
19	24	X		18	8.08	1	13	6	151	17	1504	10	382	34	2050	-	7	9	18	34	55	254	7	465	13	12
20	27	X		19	5.13	3	140	3	131	7	363	20	708	33	1342	-	-	-	77	77	112	262	22	455	38	36
21	28	X		22	2.23	-	-	-	-	1	120	7	532	8	652	-	-	-	31	31	86	293	39	440	58	56
22	30	X		28	1.60	2	111	-	-	4	250	6	213	12	574	-	-	-	-	-	0	359	0	423	0	0
23	38	X		23	0.83	-	-	-	-	-	-	6	241	6	241	-	-	-	-	-	0	290	0	416	0	0
AVERAGE				33																				426		

NOTES:

* All Team Tracks observed were, during period of observations, practically filled with cars so the length of Team Tracks can be considered to vary with the total number of cars on the tracks.

▣ This Driveway is 28 ft. wide for .75 of its length and for the remainder is 33 ft. wide.

◑ "Short Trucks" were assumed as those less than 17 ft. long. All longer trucks were classed as "Long Trucks."

TABLE 2—POSITION OF LONG TRUCKS (OVER 17 FT. IN LENGTH) AT CAR DURING LOADING PERIOD, IN VARIOUS WIDTHS OF DRIVEWAYS

Width of Driveway	Total Long Trucks	Right Angle		Skew		Parallel	
		No. of Trucks	Per Cent.	No. of Trucks	Per Cent.	No. of Trucks	Per Cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
15	35	2	6	26	74	7	20
20	17	..	..	4	24	13	76
22	29	9	31	19	66	1	3
24	257	59	23	161	63	37	14
25	30	3	10	22	73	5	17
27	89	31	35	56	63	2	2
28	168	55	33	76	45	37	22
30	24	3	13	20	83	1	4
35	8	3	37	4	50	1	13
40	20	12	60	8	40	..	..
TOTAL	677	177	26	396	58	104	15

TABLE 3—RELATION BETWEEN NUMBER OF CARS AND NUMBER OF VEHICLES SERVING TEAM TRACKS

Study No.	Width of Driveway Ft.	Total Number of Vehicles in the Driveway at one Time, Shown in Per Cent. of Total Number of Cars on the Tracks		
		Average for Entire Period of Observation	Average for Peak Period (Time Period Given In Table 1)	Maximum
(1)	(2)	(3)	(4)	(5)
1	15	4.1	11.4	20.0
2	20	7.1	10.9	15.0
3	22	8.0	19.7	23.8
4	22	9.7	19.3	21.0
5	24	11.6	17.8	22.5
6	24	10.2	16.6	18.0
7	24	8.3	18.2	22.5
8	27	17.8	23.1	32.2
9	27	14.1	17.3	25.0
10	28	15.3	18.1	25.5
11	35	8.4	14.1	17.1
12	40	8.1	18.8	40.7
13	40	5.3	21.6	24.8
14	24	24.2	36.1	59.1
15	24	17.7	36.4	58.4
16	24	19.8	28.7	52.2
17	24	11.7	19.6	30.0
18	24	14.4	26.6	36.0
19	24	22.4	23.5	38.7
20	27	15.8	24.4	36.8
21	28	19.6	34.6	49.0
22	30	9.3	21.3	28.6
23	38	4.0	21.2	26.2
AVERAGE		12.9	21.7	31.4

fact should receive major consideration in the design of team-track facilities. Obviously the longer the open-ended driveway becomes, the more nearly it approaches, in effect, two stub-ended driveways joined at the stub ends. The shorter the driveway the less liability for delays. It is recommended, therefore, that wherever possible stub-ended driveways be avoided. It is recognized that intermediate cross driveways are objectionable in that they require the cutting of cars and some decrease in capacity, but it is felt, nevertheless, that where team tracks are more than 20 cars long (per single track) that intermediate cross drives should be introduced. In large team-track developments where exceptionally long tracks are provided, cross drives should be introduced, so that 14 cars per track is the maximum length between any two drives.

The desirability of having numerous cross drives becomes less pronounced as the width of driveways increases and it ceases to be an important factor when driveways are sufficiently wide to preclude the possibility of delays. Through routes that entail the crossing of tracks by vehicles other than those using the team tracks should be avoided.

In laying out team-track facilities, the desirability of being able to switch cars with minimum disturbance to the remaining cars should not be overlooked. In yards where only night switching is employed, this factor is not important.

Certain types of commodities, such as large rolls of paper, and heavy machinery, frequently necessitate the trucks approaching the car at right angles. Other commodities, such as produce, can be handled satisfactorily with the trucks standing at an angle to the car. Certain other commodities such as brick, sand, stone, coal, and lumber, can be loaded to advantage with trucks parallel to the cars. In team tracks where this last class of commodities is handled exclusively, allowance can be made for this type of unloading in determining team-track widths. If this can be done material economies will result.

Fig. 1 shows the relation between the angle of loading of a vehicle and its occupation of the driveway. For a vehicle of the assumed dimensions (7.5 ft. wide by 25 ft. long) it will be observed that where the angle of loading between the truck and car is more than 56 degrees and less than 90 degrees there is a slightly greater occupation of driveway than when the truck is at 90 degrees to the car. The angle of loading at 45 degrees only decreases the occupation of the driveway by two feet. In other words, the angle of loading of the vehicle to be of material value in decreasing the occupation of driveway must be 45 degrees or less and where it is necessary to decrease materially the occupation of the driveway, as would be the case with long trucks in narrow driveways, the angle of loading must be relatively small. But such a heavy skew tends to increase the objection to the narrow driveways from the standpoint of the driver. In the case of the heavy skews it is necessary to use the tail gate on the truck as a bridge between the truck and the car. Observations indicate that approximately 40 per cent of the trucks are equipped with tail gates and approximately 10 per cent with side gates, making them adaptable to skew or side loading respectively.

From the observations made it does not seem wise at this time to recommend generally driveway widths that will necessitate side loading of trucks, though the advantages of this form of loading from the standpoint of the railroads are obvious. The observations, which are corroborated by the information shown in Table 1, indicate that a width of driveway should be provided that will allow the longest trucks to stand backed up to the car at practically 90 degrees and, at the same time, leave sufficient space between the front of the truck and the opposite car to permit another truck to pass. This, generally speaking, should be the minimum width that should be provided. Any addition to this width will add to the ease with which trucks can be manipulated in the driveways. It might be contended that the width of a driveway should be sufficient

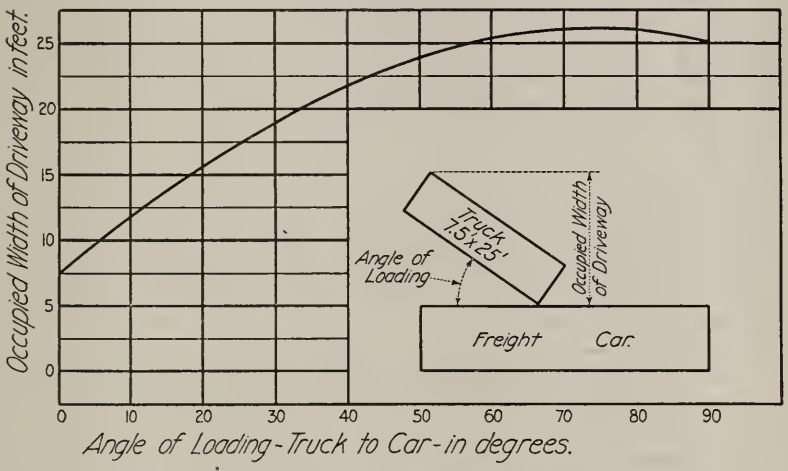

Fig. 1.—Relation Between the Angle of Loading of a Vehicle and Its Occupation of the Driveways

to permit trucks to back up to cars on both sides of the driveway, and at the same time leave sufficient clear space between for the passage of trucks. This situation might be justified in unusual cases where the handling of the business is confined to a relatively short period of the day, resulting in a very heavy traffic.

Team-track detention generally is from two to three days. Assuming an average team-track detention of 2.5 days per car, an average of 6 truck loads per car, and a team track accommodating 10 cars per track (a total of 20 cars for the driveway), then there would be an average of only 48 trucks in and out of the team track per day. This explains the low average number of trucks per car as shown in Column 3 of Table 3, which is an analysis of the vehicle occupation of the team tracks observed and shown in detail in Table 1.

It is interesting to note in this connection that the period in which the number of teams in the driveways equaled or exceeded 15 per cent of the number of cars on the tracks amounted to only 29 per cent of the

periods of observation. Columns 4 and 5 of Table 3 show an analysis of this comparatively short period of more intense traffic. It should be borne in mind also that the team tracks observed were selected out of a large number because of their relatively dense traffic. In the large number of observations made, there were very few times when delays were occasioned by trucks backing up simultaneously to opposite car doors. In some of the cases when this did occur, the trucks could have been skewed so as not to result in blockades even though the driveway were considerably narrower than the total length of the two trucks.

Table 1 shows that no delays were experienced in driveways where the width exceeded 30 ft. during the period of observation covered by the table. Delays, however, do occur when the width of driveway is less than sufficient to provide a clear passageway in front of a truck backed up perpendicularly to the car. The effect of wide driveways was strikingly observed in the case of team track 10 (Table 1). Here the driveway is 28 ft. wide for approximately three-fourths of its length and 33 ft. for the remainder, and there was a relatively great amount of delay, when its width is taken into consideration. Taking the length of the period of observation into consideration, the traffic on this driveway was intense. During the entire period of observation, all delays noted occurred on the 28 ft. width of driveway, which showed that the addition of 5 ft. of width eliminated delays under the conditions experienced in this driveway. The team-track foreman stated that, where cars were consigned to certain companies using long trucks, he frequently went to the trouble and expense of additional switching in order to place these cars along the portion of the team track where the driveway was 33 ft. wide.

Table 4 presents information on the effect of the width of driveway on costs and utilization of property, and shows the extravagance of unnecessarily wide driveways.

On account of the foregoing facts, the added cost of providing the wider driveways, and, in many cases, the resulting decrease in capacity with such a small amount of resulting benefit, it does not seem wise to recommend a width determined by providing a straight clear driveway between trucks backed up simultaneously on opposite sides of the driveway.

With this general conclusion reached, it next becomes desirable to study the length and width of trucks now using driveways and the tendency in truck design, in order to select the dimensions of trucks that should be used in determining the proper width of driveways.

A study, quite similar to the one now being presented, was made of several of the Chicago team tracks in 1920. The investigation was sufficiently general to indicate the types of vehicles using Chicago team-track driveways at that time. This information compared to that obtained in the 1927 investigation is shown in Table 5.

Table 6 shows the number of horse-drawn vehicles and motor trucks operated in Chicago from 1910 to 1926 as reflected by vehicle-tax registration.

Both of these tables show a pronounced tendency for motor trucks to replace horse-drawn vehicles. There are still many horse-drawn vehicles using team tracks, though the four-horse vehicles and to a large extent the three-horse vehicles have, for all practical purposes, disappeared. The trend of recent years would indicate that, in large centers of population, motor trucks, to a great extent, will eventually replace horse-drawn vehicles.

TABLE 4—EFFECT OF TEAM-TRACK DRIVEWAY WIDTHS ON TEAM-TRACK COSTS AND SPACE OCCUPIED

Width of Driveway	Cost of Track and Pavement Per Car of Standing Capacity	Cost of Team Yards (Track, Pavement, and Value of Land) in Dollars per Car of Standing Capacity, with Land Value Indicated				Area of Land Required Per Car of Standing Capacity Sq. Ft.
		$0.50 per Sq. Ft.	$1.00 per Sq. Ft.	$5.00 per Sq. Ft.	$10.00 per Sq. Ft.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
30	517	1113	1710	6480	12442	1193
35	574	1227	1879	7099	13624	1305
40	630	1339	2048	7718	14805	1418
45	686	1451	2216	8336	15986	1530
50	742	1563	2385	8955	17167	1643
55	799	1677	2554	9574	18349	1755
60	855	1789	2723	10193	19530	1868

Assumptions:

Track centers—13 ft. and width of driveway plus 10 ft.
Track length occupied—per car—45 ft.
Cost of track—$4.00 per ft.
Cost of pavement—$4.50 per sq. yd.

In 1921 at a Chicago freight house, 47 vehicles were measured. Similar information has been compiled in 1927 and is compared with the 1921 data in Table 7. This comparison indicates that the average length of motor trucks has not changed materially in the past six years. An analysis of the length of trucks measured in 1927 indicates a distribution between various over-all lengths as follows:

Less than 20 ft.—49.8 per cent
20.0 to 20.9 ft.—14.8 per cent
21.0 to 21.9 ft.—10.0 per cent
22.0 to 22.9 ft.—12.7 per cent
23.0 to 23.9 ft.—4.4 per cent
24.0 to 24.9 ft.—6.6 per cent
25.0 to 25.9 ft.—1.3 per cent
26.0 to 26.9 ft.—0.4 per cent

As it is possible to turn horses hitched to a wagon so that their length does not function in blocking the driveway, it is evident that the width of team-track driveways should be determined by the requirements of motor trucks.

An investigation has been made in conjunction with the Motor Truck Association of Illinois to determine the probable future length of trucks

TABLE 5—COMPARISON OF TYPES OF VEHICLES USING CHICAGO TEAM TRACKS IN 1920 AND 1927

Year	HORSE-DRAWN VEHICLES								MOTOR TRUCKS						Grand Total
	1-Horse Wagons		2-Horse Wagons		3-Horse Wagons		Total Wagons		Short Trucks Shorter than 17 ft.		Long Trucks Longer than 17 ft.		Total Trucks		
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1920	270	21.9	487	39.5	14	1.1	771	62.5	123	10.0	339	27.5	462	37.5	1233
1927	162	9.1	314	17.5	28	1.6	504	28.2	283	15.8	1003	56.0	1286	71.8	1790

TABLE 6—REGISTRATION OF HORSE-DRAWN VEHICLES AND OF MOTOR TRUCKS IN CHICAGO AS SHOWN BY VEHICLE-TAX LICENSES

Year	1-Horse Wagons	2-Horse Wagons	3-Horse Wagons	4-Horse Wagons	Total Number	%	1 Ton and Under	Over 1 Ton	Total Number	%	Grand Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1910	40,109	17,640	331	34	58,114	99	436	363	799	1	58,913
1912	38,429	16,728	325	20	55,502	95	1,680	1,515	3,195	5	58,697
1914	36,789	14,984	231	17	52,021	91	3,072	2,003	5,075	9	57,096
1916	32,917	13,528	210	11	46,666	81	7,447	3,651	11,098	19	57,764
1918	22,653	9,465	205	8	32,331	66	9,749	6,629	16,378	34	48,709
1920*	18,814	1,383	191	3	20,391	47	13,516	9,316	22,832	53	43,223
1922	18,623	6,244	123	2	24,992	42	22,549	11,946	34,495	58	59,487
1924	15,747	5,209	114	1	21,071	32	29,365	15,566	44,931	68	66,002
1926	11,840	3,372	64	0	15,276	23	33,802	17,278	51,080	77	66,356

*For 8 months only (May 1st to Dec. 31st.)

to be used in freight-house and team-track operation. A committee of representatives of the principal motor truck manufacturing companies was appointed. This joint committee also conferred with representatives of the Cartage Exchange of Chicago. Several meetings were held with this Committee, and questionnaires were submitted to members of the Cartage Exchange and several of the leading motor-truck manufacturers. As a result of this investigation, the following information relative to the trend in motor-truck construction has been compiled.

Table 8 shows the production and registration of motor trucks in the United States and Canada since 1906. Table 9 shows the number of trucks of various capacities manufactured in the United States and Canada.

Table 7—Comparison of Length of Vehicles Using Chicago Freight Houses in 1921 and 1927

Type of Vehicle	Number of Vehicles Observed		Average Length Feet	
	1921	1927	1921	1927
Horse Drawn Vehicles.....	22	173	24.71	24.06*
Motor Trucks.....	25	252	20.51	20.11

*35 one-horse vehicles averaged 19.43 ft. and 138 two-horse vehicles averaged 25.24 ft

Table 8—Motor Trucks Manufactured and Registered in United States and Canada

Year	Number Manufactured	Number Registered
1906.....	500	1,100
1910.....	6,000	10,000
1914.....	25,375	85,600
1918.....	227,250	525,000
1922.....	249,228	1,375,725
1926.....	491,353	2,764,222

Above information obtained from National Automobile Chamber of Commerce.

Motor trucks designed for the handling of freight logically divide themselves into two classes so far as influence of operating requirements on size of truck is concerned. In one class, the motor trucks are used as competitors of railroads, i. e., for long haul. This use of the motor truck is relatively new and there is some question if the most desirable form of truck has as yet been devised. The tendency of this kind of operation is towards larger trucks. The legal limitation as to wheel loads seems to be the problem confronting the truck manufacturers. To meet this situation the six-wheel truck is being developed. Obviously, there is some question as to what the limit for this type of truck will be. Tractors and trailers are also used rather extensively in this service. In the second class, the motor truck is used for local distribution of freight. Trucks serving freight houses and team tracks, for the most part, come under

this classification. These trucks are required, in making deliveries, to operate through busy city streets and in many cases through city alleys. This places certain restrictions on the size of these trucks. The use of motor trucks in this class of service has passed the experimental stage and there has been little change in motor-truck design, so far as length and width of trucks are concerned, in the past several years. It is the opinion of both the manufacturers and the users of these trucks that the present size of truck is well adapted to the requirements, and it is felt that there will not be a great tendency to increase the length of trucks over the maximum length now being used, except in special cases, which will be so infrequent as not to warrant consideration in this problem. The use of tractors and trailers in freight-house and team-track operation has become quite common. This form of truck will not be a limiting factor in determining driveway widths.

The maximum overall length of motor trucks manufactured today by principal truck manufacturers range from 25 to 27 feet, and practically all truck manufacturers feel that this maximum length is close to the limit of practicability for trucks used in freight-house and team-track operation.

The maximum overall size of truck recommended for determining team-track driveway widths is 8 x 27 ft.

In order to ascertain the present practice as to driveway widths, a questionnaire (Exhibit 1) was sent to the Chief Engineers of American railways. Information was requested only on driveways built since 1920 or now proposed. Replies covering team-track installation at 117 different points were received from 27 roads. A tabulation was made of those driveways that were reported as giving satisfactory service and that were of a form permitting comparison with others of a similar type. The result is summarized in Table 10, from which it will be observed that about 59 per cent of all driveways reported are open-ended. The tabulation has been prepared on two bases. The first, which is in detail, considers each driveway as a unit. The second, which is in summary only, considers each installation as a unit, all driveways in each installation being represented by the average width of all driveways in that installation. On the first basis, approximately 67 per cent of all driveways are from 30 to 42 ft. in width, the average width being 37.6 ft. On the second basis, the average width is 38.8 ft. Fourteen driveways ranging in width from 20 to 31 ft. were reported as not giving satisfactory service. Practically all driveways less than 26 ft. were reported as not giving complete satisfaction. One Chief Engineer advised that, in certain regions of Canada, the motor truck had not replaced, to any great extent, the horse-drawn vehicle, and that side loading of wagons was used extensively. He reported that as a result of these conditions 30 ft. driveways, and in some cases 20 ft. driveways, were satisfactory. It is evident that, if side loading of trucks could be made the universal practice, 30 ft. driveways would be adequate and material economy would result. Most cartage companies are agreed that, outside of heavy machinery, there is only a relatively

TABLE 9—NUMBER OF MOTOR TRUCKS OF VARIOUS CAPACITIES MANUFACTURED IN UNITED STATES AND CANADA

Size	1919		1920		1921		1922		1923		1924		1925		1926	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
¾ ton or less	66,436	21.0	61,187	19.0	33,809	23.2	62,194	25.0	44,198	11.5	40,324	11.1	47,135	10.0	64,141	13.1
1 ton....	148,091	47.0	164,240	51.0	79,844	54.6	147,114	59.0	274,559	71.1	265,756	73.0	342,774	72.5	317,900	64.6
1½ ton..	26,891	8.5	35,174	11.0	5,608	3.8	4,388	1.8	24,031	6.2	20,193	5.6	29,029	6.1	46,658	9.5
2 ton....	31,636	10.0	25,763	8.0	11,206	7.7	13,830	5.5	14,998	3.9	8,118	2.2	12,298	2.6	23,174	4.7
2½ ton..	17,400	5.5	12,871	4.0	3,958	2.7	11,235	4.5	12,516	3.3	14,105	3.9	16,478	3.5	15,758	3.2
3½ ton..	12,022	3.8	12,893	4.0	3,343	2.3	3,319	1.3	6,761	1.7	3,526	1.0	5,958	1.2	6,711	1.4
5 ton....	9,175	2.9	6,441	2.0	4,714	3.2	5,718	2.3	4,611	1.2	6,548	1.8	7,887	1.7	6,834	1.4
Over 5 ton and spec.	4,113	1.3	3,220	1.0	3,600	2.5	1,430	.6	4,081	1.1	4,960	1.4	11,595	2.4	10,177	2.1
	316,364	100	321,789	100	146,082	100	249,228	100	385,755	100	363,530	100	473,154	100	491,353	100

Above information obtained from National Automobile Chamber of Commerce.

TABLE 10—TEAM TRACKS CLASSIFIED AS TO WIDTH OF DRIVEWAY, REPORTED AS HAVING BEEN BUILT SINCE 1920 AND GIVING SATISFACTORY SERVICE

Type of Driveway	Length of Driveway in Standing Car Capacity of Single Track	Width of Driveway in Feet										
		26-29	30-33	34-37	38-41	42-45	46-49	50-53	60	64	90	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Stub-ended	30 cars or more	2	.....	.....	1	.....	.....	.....	.....	.....	.....	3
"	20-29 cars	1	13	.....	2	1	.....	.....	.....	.....	.....	17
"	10-19 cars	8	11	7	14	2	.....	2	.....	.....	.....	44
"	Less than 10 cars	5	2	.....	3	1	.....	.....	.....	.....	.....	11
	TOTAL all lengths.....	16	26	7	20	4	.....	2	.....	.....	.....	75
Open-ended	30 cars or more	.....	3	.....	1	.....	1	1	.....	2	1	9
"	20-29 cars	.....	12	3	5	2	13	1	.....	.....	.....	36
"	10-19 cars	2	17	9	14	4	1	1	2	.....	.....	50
"	Less than 10 cars	1	5	1	5	.....	.....	.....	.....	.....	.....	12
	TOTAL all lengths.....	3	37	13	25	6	15	3	2	2	1	107
	Total all lengths Open and Stub ended.....	19	63	20	45	10	15	5	2	2	1	182
Classification of above team tracks shown by yards (average driveway width indicated) and not by individual team tracks.		12	16	9	18	8	4	4	1	2	1	75

small amount of team-track business that could not be handled by side loading if the trucks were designed to accommodate such form of loading. It is, therefore, very advantageous to railroads to encourage truck manufacturers to produce truck bodies suitable for side loading.

Four Chief Engineers volunteered recommendations for team-track driveway widths as follows: 40 ft.; min.—40 ft., max.—60 ft.; vary from 32 to 42 ft.; and 45 ft.

One of the principal cartage companies of Chicago reported "It is our belief that the railroads should make their driveways at least 35 ft., and wider if space permits. They should also have cross driveways connecting the several driveways at not more than 600 ft. apart." Another very active member of the Cartage Exchange of Chicago recommends a minimum driveway width of 40 ft.

It has been recommended previously that a truck 8 x 27 ft. be used in determining driveway widths. For trucks eight feet in width, a clear driveway of at least ten feet should be provided. One truck backed up to a car, and having a clear 10 ft. passageway in front of it, would require a minimum driveway of 37 ft. Any increase in this width will add to the ease in manipulation of trucks and will assist in the longitudinal movement of trucks along driveways on which trucks are backed up to cars on both sides. As previously stated, a width of driveway sufficient to accommodate two trucks backed up simultaneously to opposite sides of the driveway is not justified, except in special cases.

Based on the information here presented it is recommended that the clear width of driveway for the various conditions be as follows:

A Where side loading is employed:
- For driveway alongside of one track.....20 ft.
- For driveway between two tracks.....30 ft.

B Where side loading is not universally followed:
- Normal Conditions,
  - For driveway alongside of one track.....37 ft.
  - For driveway between two tracks.....40 ft.
  - For backing-up space along a public thoroughfare .....27 ft.
- Where land value is high,
  - For driveway between two tracks.....35 ft.

Track centers, where the driveway is located between tracks, should be ten feet greater than the width of driveway.

The spacing of tracks, where multiple team tracks are built, may be fixed by regulatory bodies, but it is recommended that the minimum distance between track centers be 13 ft., if it is desired to open refrigerator-car doors for inspection on both sides of the cars.

FREIGHT-HOUSE DRIVEWAYS

The determination of proper width of driveways for freight houses is subject to more variables and is, therefore, more difficult than the

determination of proper driveway widths for team tracks. There is frequently a tendency to use freight-house driveways as reservoirs for the storage of waiting trucks when there is not tailboard space available. As a general proposition, freight-house traffic is much more intense than that for team tracks. In many freight houses, the tailboard frontage is used to capacity. In others, particularly those used exclusively for inbound business, the house is used also as a storage warehouse, which may tend to reduce the driveway requirements.

In team tracks, skew loading in narrow driveways often is used without seriously impairing their usefulness. In freight houses, on account of the relatively large amount of teaming and the rather common practice of providing continuous doors on the tailboard side of the house, there is a greater necessity for square loading of trucks. Side loading, as previously pointed out, can be used to advantage in team tracks for certain types of commodities, but in freight houses it is used very infrequently on account of unduly obstructing the tailboard.

Desirability of making driveways double-ended is as true for freight houses as for team tracks. The desirability of having multiple approaches to freight-house driveways varies directly with the length of the freight houses. For this reason, and on account of the large amount of trucking, a large percentage of freight houses are located adjacent to public streets. In some cases, where the street is not a thoroughfare, only sufficient space is allowed for backing up the trucks without blocking the sidewalk. In such installations the sidewalk, on the freight-house side of the street, is eliminated.

The information as to those freight-house driveways which are comparable, collected in response to the questionnaire referred to above, is summarized in Table 11. This table includes only those freight houses built since 1920 where the width of driveway is reported as satisfactory by the Chief Engineer. Replies were received from 20 roads submitting information on 70 freight houses. Four driveways were reported as insufficient, their widths being 34, 37, 45 and 47 ft. The average width of the driveways of the 49 freight houses listed in Table 11 is 46 ft. One freight house (not included in Table 11) had a driveway 57 ft. wide between and serving two houses. The driveway was reported as being satisfactory. The tendency to locate freight houses adjacent to public streets was demonstrated by the replies received. Of the 65 freight houses reviewed 10 or 15 per cent were located alongside a public street. The driveway width provided adjacent to the street for "backing-up space" ranged from 15 to 40 ft. and averaged 22 ft.

The table shows that the width of driveway did not vary in proportion to the length of house. But unless multiple entrances are provided for the driveway, consideration should be given to increasing the width of stub-end driveways at the entrance end.

Obviously, the minimum width of a freight-house driveway should be sufficient to provide for trucks backed up to the freight house at right angles and to provide room in front of the truck for two trucks to pass. On the basis of the size of truck adopted in the foregoing analysis, which

applies equally well to freight-house operation, a freight-house driveway with tailboard on one side would require a minimum width of 47 ft. If the driveway serves tailboard space on both sides, the width should be 70 ft. At short houses, where the volume of teaming will be light, it might be possible to decrease these widths slightly. However, it would be unwise to recommend lesser widths for driveways 400 ft. or more in length unless provision can be made for one-way traffic, which is a special case that is not considered in this report. If the freight house is several hundred feet long, has a stub-end driveway, and there is a probability of trucks standing in the driveway for any length of time, serious consideration should be given to increasing the width of driveway beyond the widths given above. For a freight house located alongside a public street, 27 ft. should be provided for free back-up space.

In this report no consideration has been given to widths of freight-house driveways in which columns supporting air-right buildings are

Table 11—Freight House Driveways, Classified as to Widths, Reported as Having Been Built Since 1920 and Giving Satisfactory Service

Length of Tailboard Feet	Widths of Driveway in Feet											Total
	30 or Less	31 to 35	36 to 40	41 to 45	46 to 50	51 to 55	56 to 60	61 to 65	70	80	91	
Less than 100	4	1	....	....	....	....	....	....	....	....	....	5
100 to 299	2	3	5	2	....	....	....	2	1	....	....	15
300 to 499	....	3	2	3	2	1	1	1	1	1	1	16
500 and over	2	....	2	1	3	2	1	2	....	....	....	13
Total all lengths	8	7	9	6	5	3	2	5	2	1	1	49

located. There are several such installations in existence and there probably will be a tendency to increase the development of property above freight facilities. Such developments are special cases, which must receive individual attention. Other considerations, such as the cost of supporting the air-right building, become major factors influencing the location of the columns. Therefore, it is not desirable to develop this feature of the subject, though the information given relative to widths and lengths of trucks will be of value in the solution of this problem.

Conclusions

1. Team-track driveways normally should be of a sufficient width to allow the longest trucks using the driveway to stand at right angles to the car, with sufficient space remaining in front of the truck to allow another truck of maximum width to pass.

2. Team-track driveways of sufficient width to enable two maximum-size trucks to load opposite each other at right angles to the cars, and with a clear passageway between them for the passing of a maximum-width truck, are not justified economically except in special cases where an extremely intensive truck traffic is handled.

3. There probably will not be any further tendency to increase the maximum size of trucks now being operated in team-track and freight-house service. The maximum overall size of truck recommended for determining team-track and freight-house driveway widths is 8 x 27 ft.

4. Outside of heavy machinery, heavy rolls of paper, and similar shipments, practically all commodities handled on team tracks are adapted to side loading of trucks.

5. At present only about ten per cent of the trucks used in team-track service are adapted to side loading.

6. It is not advisable at the present time to recommend generally a width of team track based on exclusive side loading of trucks, though the economic advantages of this method of loading from the railroad's standpoint are obvious. Truck manufacturers should be encouraged in the building of trucks adapted to side loading.

7. The following clear width of team-track driveways are recommended for the various conditions indicated:

(A) Where side loading of trucks is employed exclusively:
For driveway alongside one track.....20 ft.
For driveway between two tracks.....30 ft.

(B) Where side loading of trucks is not universally followed:
Normal conditions,
For driveway alongside one track.....37 ft.
For driveway between two tracks.....40 ft.
For backing-up space alongside a public thoroughfare .....27 ft.
Where land value is high,
For driveway between two tracks.....35 ft.

8. The distance between track centers where the driveway is located between tracks, should be ten feet greater than the width of the driveway.

9. The spacing of tracks, where multiple team tracks are built, may be fixed by regulatory bodies, but it is recommended that the minimum distance between track centers be 13 ft.

10. Stub-ended driveways serving team tracks should be avoided. Where team tracks are more than 20 cars long (per single track), intermediate connecting cross drives should be provided. In large team-track developments where exceptionally long tracks are provided, cross drives should be introduced so that 14 cars per track is the maximum length between any two drives.

11. The maximum width of a freight-house driveway should be sufficient to provide for trucks backed up to the freight house at right angles and to leave room in front of the truck for two trucks to pass.

12. Freight-house driveways should be of the following minimum widths for the various conditions indicated:

(A) With tailboard on one side.....47 ft.
(B) With tailboard on both sides.....70 ft.
(C) Free back-up space alongside a public street..27 ft.

Exhibit No. 1

QUESTIONNAIRE

1. List team tracks and freight houses built by your company since 1920 or now planned for immediate or early construction. Prints showing the widths of driveways and lengths of tracks served with entrance and exit facilities should accompany the questionnaire for the analysis of the Committee.

2. Did the question of increased length of motor trucks receive serious consideration in the determination of the adequate width of driveways provided in these facilities?

3. In your judgment was the width provided ample or were there other limitations such as limit of the size of property or value of land that restricted the width to less than should have been provided?

4. Has the width of these driveways proven ample?

5. State the general character of business handled on each driveway or give any other information that might be of interest in a study of driveway widths.

Appendix E

(5) SCALES

M. J. J. Harrison, Chairman, Sub-Committee; J. E. Armstrong, A. Bousfield, C. A. Briggs, A. W. Epright, E. M. Hastings, H. O. Hem, E. K. Lawrence, H. M. Roeser, H. R. Saunders.

The assignments to this Sub-Committee for the current year's work were as follows:

(5) Specifications for various types of scales used in railway terminals.
(6) Study and report upon the disposition of track scales which have been removed by reason of inadequacy, obsolescence or inaccuracy.

Your Committee has nothing to report at this time in connection with assignment (5), and the following, therefore, pertains entirely to assignment (6), which assignment resulted from the following communication from the Director of the U. S. Bureau of Standards to the Secretary of the American Railway Association on January 19th, 1927.

"In conducting our railroad track scale testing program, we occasionally come across reported instances where track scales of antiquated design or obsolete types, discarded by carriers, have been sold either directly by the carriers to industrial concerns or have reached industrial concerns through a scrap jobber. Such instances sometimes result in rather unfortunate consequences.

"For instance, an industrial concern that may have purchased such a scale in good faith faces the possibility of having its weight agreement refused by either the carrier who sold the scale, or other carriers, on the ground that the scale is inadequate for modern freight weighing requirements. Again, a carrier who has disposed of such a scale because of lack of suitability for its own requirements may later find itself accepting weights over the scale after having disposed of it for scrap. This, we understand, has rather frequently occurred after scales have gone through the hands of scrap jobbers.

"In any event, these instances are probably due to inadvertence and the loose articulation of railroad organizations, one department of which usually condemns a scale, another disposes of it, and yet another makes and supervises weight agreements.

"While some of these cases have come to us both formally and informally as complaints, we do not, of course, have regulatory control over such matters, nor does it appear in any event that the circumstances justify invoking governmental authority to remedy the situation.

"Might it not be a good idea to lay the matter before responsible railroad officials through your association? The incongruities are obvious. A practical remedy is for each carrier to issue instructions to its responsible officers that all weighing machinery to be disposed of for scrap or other purposes be first demolished beyond possibility of repair."

It will be noted that, while Director Burgess' letter refers only to the sale of inferior scales to industrial concerns, assignment (6) quoted above is somewhat more general in scope. Therefore the following are stated as the possible methods of disposing of a track scale which has been removed for the causes stated:

1. Sell as scrap metal after being rendered unfit for further use as a scale or parts thereof.
2. Retain for use as repair parts of existing scales of the same type and size.
3. Retain for working over the parts into motor truck and other similar scales.
4. Re-install in a new location.
5. Sell as scrap metal in the same condition as when removed from service.
6. Sell as a scale in the same condition as when removed from service.
7. Repair and sell as a complete scale.

In considering these various methods of disposition, it is immediately evident that method No. 1 requires no comment whatever in this discussion, except to the effect that it is entirely proper and justifiable.

The same comment applies also to method No. 2, except that, obviously, the necessity for so utilizing the old parts will gradually diminish with the decrease in the number of obsolete track scales retained in service.

As to method No. 3, examination of the motor truck scale specifications adopted by this Association in 1923, together with the slightest familiarity with the type of track scales covered by this discussion, will at once indicate the practical undesirability of this method.

The inclusion of method No. 4 in this discussion presupposes the exercise of an option by the individual carrier. However, it should be kept in mind that the railways in general have expressed their views as to what sort of track scales they desire to install when a new scale is necessary. This choice is represented by the 1920 track scale specifications of the American Railway Engineering Association (pages 696-716 of the 1921 Manual, A.R.E.A., or Circular No. 83 of the U.S. Bureau of Standards), which specifications have become, through general acceptance, the standard track scale specifications of the country. These were supplemented by the additional specifications which were reported (Vol. 28, 1927 Proceedings) to and adopted by the 1927 convention of this Association.

All of these specifications are descriptive of the details which go to make up the completely assembled scale, and it is reasonable to say that there was at least one good reason for the adoption of each item contained therein. Some of these reasons had to do directly with the ability of the scale to weigh correctly at the time of installation. Others had to do directly with the life of the scale, or the period over which the scale would continue to weigh correctly. It may be said, however, that the composite specifications represented the judgment of those assumed to

know as to what would result in a weighing machine which would require the smallest initial investment consistent with its ability to weigh correctly during a reasonable period of time, and which would not require more maintenance attention during that period than could, under ordinary circumstances, be practicably provided. In other words, the intent of the specifications was clearly to provide a scale which would result in the maximum net economy during its useful life.

There is no record of any serious criticism during the past seven years of any section of the present standard specifications, and this is certainly evidence of their fundamental soundness. Then, since both the railways and the general public have so universally accepted the present track scale specifications as is clearly evident, the question is pertinent as to how a railway can consistently justify the installation by itself of a scale which does not embrace the details which have been accepted as being correct. Apparently there can be but one answer to this question, and that answer must be to the effect that the reinstallation of the old scale is not justified.

Before discussing methods Nos. 5, 6 and 7, it is necessary that the situation regarding installation of track scales by industries be examined, and it also seems desirable to ascertain why an industry should install a track scale in the first place. Your Committee finds that, except for intra-plant accounting purposes, the installation of a track scale is rarely undertaken by an industry unless it wishes to have its weights recognized by the railways. Such recognition is accomplished through the medium of a properly supervised weight agreement, set up in some cases between the industry and the directly interested carrier, but more generally between the industry and the Inspection and Weighing Bureau having local territorial jurisdiction for the account of the various railways operating in that territory. The several Inspection and Weighing Bureaus function independently of one another, but have a common meeting place in the Traffic Division of the American Railway Association.

The various forms and blanks used by the Inspection and Weighing Bureaus in consummating their industry track scale weighing agreements have been examined by your Committee, and it is found that while these forms outline the terms and conditions under which the industry track scale weights will be recognized, in none of them is there any specification or reference which governs the type, capacity or length of the scale on which the weights are to be obtained. Except for such supervision as is exercised within its boundaries by the State of Minnesota, the sole requirement for industry track scales seems to be that such scales, whatever their class or type, shall be kept in "good weighing condition." Whether or not this condition obtains is determined at comparatively infrequent intervals, and by means which, in at least some cases, are of doubtful value.

In most of the weight agreement forms, reference is made to the Track Scale Specifications and Rules of the American Railway Association, but it appears that these apply only to maintenance, operation and testing (see pages 718-720 of the 1921 edition of the A.R.E.A. Manual). It therefore seems that neither the Inspection and Weighing Bureau having

local jurisdiction, nor the railway on whose line an industry may be located, has, in general, any power to say what sort of track scale shall be used to obtain weights for revenue waybilling purposes, as long as the industry so maintains its scale that it will not be condemned by the inspector who tests it from time to time. Furthermore, the railway cannot justifiably object to the continuance in service of any given industry track scale, and recommend the suspension of the industry track scale weighing agreement, unless it can be shown that the scale is consistently weighing incorrectly.

There is frequently, if not usually, a considerable advantage to a railway in being able to accept a shipper's weights, and thus avoid the expense and delay which is often incident to weighing cars in a congested yard. It follows, therefore, that the railways should be interested in seeing that the industries, whose scale weights are accepted by the railways, are provided with proper weighing facilities, and it is also reasonable to suppose that the friendly relations which usually exist between a railway and its patrons should prompt the railway to encourage its industries to install scales which will most economically serve the needs of the industries. If it is false economy for a railway to install a so-called "cheap" scale, then it is also false economy for an industry to do likewise. It therefore appears that the railways should encourage the installation by industries of "standard" scales, and, as a means to that end, should so dispose of their worn-out and replaced scales that such scales will not fall, either directly or indirectly, into the hands of industries, the managements of which, misled by the low first cost, may easily believe that the installation of such scales will result in ultimate economy. When consideration is given to the fact that, in general, the railways have more competent men in their scale maintenance forces and better facilities for scale maintenance work than has the average industry, it is obvious that the average industry cannot practicably provide the degree of maintenance attention for a "cheap" scale which would be required and provided for the same scale under like service on the average railway, and, therefore, a scale which has been deemed unsatisfactory for railway service would be even more unsatisfactory when installed by an industry for use under like conditions.

From the foregoing considerations it is concluded that methods 5, 6 and 7, as enumerated above, are entirely devoid of merit, and that a definite recommendation to this effect should be adopted.

Conclusions

A track scale which has been removed by reason of inadequacy, obsolescence or inaccuracy, should be disposed of in either of the following ways:

1. Treat as scrap metal after rendering unfit for further use as a scale or parts thereof.
2. Retain for use as repair parts of existing scales of the same type and size.

REPORT OF COMMITTEE XXI—ECONOMICS OF RAILWAY OPERATION

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F. L. Thompson,
Barton Wheelwright,
J. L. White,
C. C. Williams,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering following subjects:

(1) Revision of the Manual. (No revisions are recommended.)

(2) Develop and report on methods for obtaining a more intensive use of existing railway facilities, with particular reference to increasing carrying capacity:

(a) Without material additional capital expenditures.

(b) With due regard to reasonable capital expenditures consistent with traffic requirements (Appendix A).

(3) Develop and report upon methods or formulas for solution of special problems relating to more economical and efficient railway operation (Appendix B).

(4) Begin study to determine the most economical makeup of track to carry various traffic densities (Appendix C).

(5) Develop suitable units for operating and equipment statistics required by Interstate Commerce Commission, to be used in cost comparison of transportation, equipment and roadway maintenance, with necessary additions thereto, collaborating with Committee XI—Records and Accounts, and Committee XXII—Economics of Railway Labor (Appendix D).

(6) Determine what volume or other conditions of business or service justifies a change from flat switching to the hump method in any given yard, collaborating with Committee XIV—Yards and Terminals (Appendix E).

(7) Study problems of railway operation as affected by the introduction of motor trucks and bus lines, with particular reference to its effect upon branch or feeder lines (Appendix F).

(8) Outline of work for ensuing year.

Action Recommended

1. No revisions of the Manual are recommended.

2. That the progress report of the Sub-Committee (Appendix A) be received as a method for arriving at operation economies realized both with and without capital expenditure.

3. That the report of the Sub-Committee (Appendix B) be received showing work accomplished.

4. That the report of Sub-Committee (Appendix C) be received as information and work on this subject held in abeyance until similar subject which was assigned to Rail Committee has been reported upon.

5. That report of Sub-Committee (Appendix D) be received as a progress report.

6. That the report of Sub-Committee (Appendix E) be received as information.

7. That the report of Sub-Committee (Appendix F) be received as information.

Recommendations for Future Work

That the same subjects be reassigned with the understanding that no work be done on No. 4 until data bearing on same is worked up by Rail Committee.

Respectfully submitted,

The Committee on Economics of Railway Operation,

James M. Farrin, *Chairman.*

Appendix A

(2) DEVELOP AND REPORT ON METHODS FOR OBTAINING A MORE INTENSIVE USE OF EXISTING RAILWAY FACILITIES, WITH PARTICULAR REFERENCE TO INCREASING CARRYING CAPACITY

(a) Without material additional capital expenditures.
(b) With due regard to reasonable capital expenditures consistent with traffic requirements.

M. F. Mannion, Chairman, Sub-Committee; B. J. Schwendt, G. E. Boyd, L. S. Rose, E. E. Kimball, J. F. Pringle, Albert Hansen, F. L. Thompson, F. H. McGuigan, B. T. Anderson, R. B. Abbott, J. N. Brand, D. M. Driscoll.

HISTORY

The primary object of this Sub-Committee's work has been to study the effects of various changes in operating conditions upon freight train performance to determine the extent to which these changes increase the traffic capacity of a railroad.

Thus far the Committee has investigated the following:

(1) The effect of the number of trains per day.
(2) The effect of the length of engine district.
(3) The effect of double-tracking.
(4) The effect of passenger train operation upon freight train performance.
(5) The effect of supervision.
(6) The effect of substituting heavy steam power for light.
(7) The effect of installing automatic signals.

This year the Committee felt that a report containing the operating statistics and physical characteristics of a heavy traffic single-track road or section of road showing what traffic can be handled on a single-track road would be very valuable. Also what improvements if any were made to increase this capacity and the effects of same.

The Committee selected the heaviest traffic section of a single-track railroad, upon which average steam railroad conditions exists, that they could find. The selection was a 48-mile single-track section of one of the large Southern roads, on which an average of 28 passenger trains and 28 freight trains were operated per day (both directions) during 1926.

(1) Study and Report on Heavy Traffic Single-Track Road

Fig. 1 is a sketch map of the road on which this study was made. The North & South Railroad trains are operated from A to C and from C to A and the East & West Railroad trains are operated from A to D and from D to A. The trains of both roads use the 48-mile single-track section AB. There are no turn-around runs between A and B and trains are not fleeted over this section.

Fig. 2 shows plan and profile of Section AB. The grade line is broken, and the grades are heavy. The sidings are lap sidings and average about 4 miles apart.

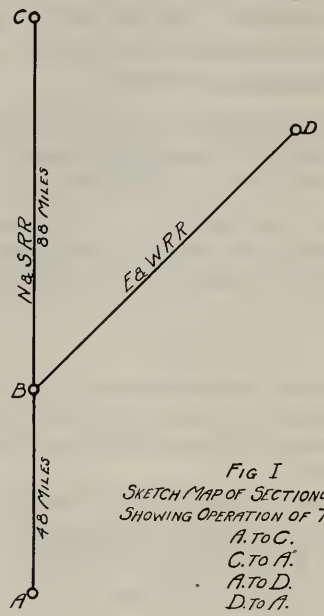

FIG I
SKETCH MAP OF SECTION OF ROAD
SHOWING OPERATION OF TRAINS
A. TO C.
C. TO A.
A. TO D.
D. TO A.

MANUAL BLOCK OPERATION

Minimum distance between passing sidings	2 miles
Maximum distance between passing sidings	5 miles
Average length of block	5 miles

AUTOMATIC BLOCK OPERATION

	Northbound	Southbound	Total or Average
Number of automatic signals	59	62	121
Average distance between signals	.81 miles	.77 miles	.79 miles

DESCRIPTION OF MOTIVE POWER

Prior to 1923:

Passenger Service

K-1-A tractive power	33,800
K-2 tractive power	39,200

Freight Service

H-9 tractive power	45,900
L-1 tractive power	50,900

Commencing in 1923 following engines were used:

Passenger Service

J-1 tractive power	53,800
J-1-A tractive power	53,800

Freight Service

L-2 tractive power	54,800
L-2-A tractive power	65,800

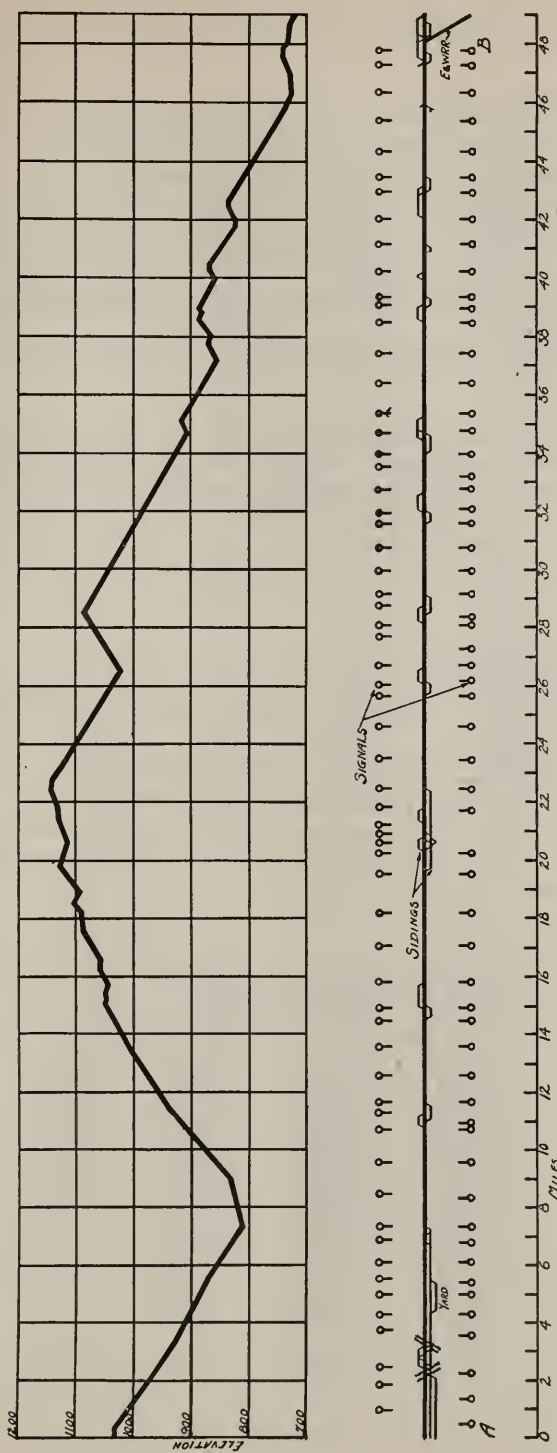

Fig 2.—Plan and Profile Section A to B

Improvements

The improvements made within the past several years to increase the capacity of this section were as follows:

Lengthening of passing tracks where necessary:
The lap siding and interlocking arrangements were installed between 1906 and 1910.
Manual block system installed about 1908.
Boiler pressure of locomotives increased from 185 lb. to 200 lb.
Boosters applied.
Main line laid with 110-lb. rail beginning in 1925 and completed in 1926.
Automatic signals installed, beginning in 1925 and completed in 1926.

Operations

The manual block system was in force from its installation in 1908 until automatic signals were completed and put into service on March, 1926. The manual block was absolute for opposing trains, also surrounding movements of passenger trains, and was permissive for movement of freight trains following freight trains.

Operations were on 31 orders. A speed limit of 35 miles per hour is in effect for freight trains.

Description of Motive Power

Passenger Service:
Pacific type, weight in working order 385,000 to 420,800.
Mountain type, weight in working order 502,000 to 519,000.

Freight Service:
Consolidation type, weight in working order 279,000 to 390,900.
Mikado type, weight in working order 420,000.
Heavy Mikado type, weight in working order 481,000.

There has been no increase in the size of motive power within the years 1922 to 1926, inclusive, except boosters were added and steam pressure increased from 185 lb. to 200 lb.

Operating Statistics

The following tables 1 to 6, inclusive, give passenger and freight train statistics for the years 1922 to 1926, both inclusive.

Table 1—Average Number Passenger Trains Daily

	1922	*1923*	*1924*	*1925*	*1926*
January	22.71	23.42	26.26	26.90	30.32
February	22.11	23.82	26.24	26.64	30.39
March	22.19	24.65	26.42	26.23	29.68
April	22.00	24.40	26.34	26.37	29.53
May	20.64	22.48	24.12	25.35	27.17
June	20.40	22.40	23.50	25.93	26.57
July	20.13	22.35	22.29	25.35	26.90
August	20.03	22.06	22.16	25.58	27.65
September	20.10	22.17	22.20	27.93	26.13
October	20.45	22.32	22.19	29.10	26.19
November	21.40	23.30	24.40	30.33	28.20
December	22.32	26.48	27.32	30.48	27.87
Total	20.93	23.32	24.47	27.18	28.03

TABLE 2—AVERAGE NUMBER FREIGHT TRAINS DAILY

	1922	1923	1924	1925	1926
January	23.26	25.45	30.03	28.32	31.61
February	27.18	26.96	32.28	29.11	33.68
March	27.20	26.52	31.13	23.71	30.55
April	21.97	27.93	26.77	25.17	29.13
May	20.48	27.74	27.00	26.49	27.25
June	22.67	26.70	25.13	25.57	26.23
July	19.68	25.35	27.42	28.94	27.35
August	21.29	26.94	25.32	27.68	27.00
September	26.13	28.53	26.80	29.47	26.23
October	26.13	29.32	27.77	31.48	26.61
November	25.43	31.27	29.73	30.60	28.87
December	28.35	29.55	26.74	31.81	26.77
Average	24.12	27.68	28.00	28.19	28.42

TABLE 3—AVERAGE NUMBER CARS PER FREIGHT TRAIN

	1922	1923	1924	1925	1926
January	29.25	30.10	32.03	36.24	36.39
February	29.68	27.68	32.57	36.56	35.18
March	27.66	31.00	32.37	39.31	37.45
April	33.89	32.10	35.42	41.72	42.93
May	33.24	31.18	34.24	39.52	40.89
June	33.31	31.01	34.40	38.44	38.00
July	34.49	34.41	35.90	38.21	43.36
August	29.39	31.58	38.49	36.57	41.21
September	27.04	30.25	36.25	34.46	37.79
October	27.20	32.60	36.17	38.24	37.69
November	27.62	32.43	35.85	37.67	38.36
December	26.99	32.04	36.91	34.63	39.39
Average	29.90	31.37	35.05	37.63	39.04

TABLE 4—GROSS TONNAGE HANDLED BY MONTHS

	1922	1923	1924	1925	1926
January	923.000	1,043,000	1,073,000	1,189,000	1,351,000
February	1,288,000	938,000	1,107,000	1,155,000	1,277,000
March	957,000	926.000	1,328,000	1,258,000	1,350,000
April	926,000	1,185,000	996,000	1,112,000	1,325,000
May	1,047,000	954,000	965,000	1,026,000	1,265,000
June	869,000	866,000	913,000	1,101,000	1,134,000
July	686,000	1,188.000	1,362,000	1,437,000	1,375,000
August	909,000	943,000	1,147,000	1,194,000	1,278,000
September	801,000	969,000	1,091,000	1,163,000	1,104,000
October	865,000	1,272,000	1,180,000	1,325,000	1,169,000
November	1,115,000	1,075,000	1,187,000	1,216,000	1,242,000
December	1,029,000	1,188,000	1,130,000	1,260,000	1,174,000
Average	911,000	1,046,000	1,123,000	1,203,000	1,254,000

Table 5—Average Freight Train Speed Miles per Hour

	1922	1923	1924	1925	1926
January	14.1	12.8	11.6	12.8	13.5
February	14.4	12.0	12.3	13.9	13.5
March	14.1	12.2	12.4	13.6	14.1
April	13.3	12.1	11.3	13.0	14.2
May	13.9	12.6	12.0	14.1	15.6
June	13.7	12.9	12.6	14.8	15.3
July	12.1	12.9	11.6	14.5	15.5
August	11.5	12.5	11.9	13.7	15.6
September	10.9	12.7	11.5	14.3	17.0
October	11.9	12.7	11.2	12.4	16.8
November	11.6	12.2	11.2	12.7	16.4
December	11.6	12.3	10.9	13.3	16.1
Average	12.8	12.5	11.7	13.6	15.3

Table 6—Average Freight Train Running Time

	1922	1923	1924	1925	1926
January	3.41	3.76	4.15	3.76	3.57
February	3.34	4.01	3.91	3.46	3.49
March	3.41	3.95	3.88	3.54	3.41
April	3.62	3.98	4.26	3.70	3.39
May	3.46	3.82	4.01	3.41	3.09
June	3.51	3.73	3.82	3.25	3.15
July	3.98	3.73	4.15	3.32	3.11
August	4.19	3.85	4.05	3.51	3.09
September	4.42	3.70	4.19	3.37	2.83
October	4.05	3.70	4.30	3.88	2.87
November	4.15	3.95	4.30	3.70	2.94
December	4.15	3.91	4.42	3.62	2.99
Average	3.76	3.85	4.11	3.54	3.15

Fig. 3 was plotted from the above tables. From this chart it will be seen that there was an increase in the number of trains, number of cars per freight train and average monthly tonnage, each year from 1922 to 1926. The average running time was longer in 1923 than in 1922 and longer in 1924 than in 1923. The effect of change in power in 1923 is shown by the increase in tonnage during 1923 and 1924. However, in 1925 the running time was less than in 1922 or 1923 while in 1926 there was a further reduction in running time over 1925.

The average road time per train for each year was plotted against the average number of trains per day, and a slope line drawn through these points, as shown on Fig. 4, 5, 6, 7 and 8. The slope lines for the different years were then all replotted on Fig. 9.

Also the average monthly tonnage for each year was plotted against the average road time per train for each year, and a slope line drawn through these points as shown on Fig. 10, 11, 12, 13 and 14. The slope lines were then replotted on Fig. 15.

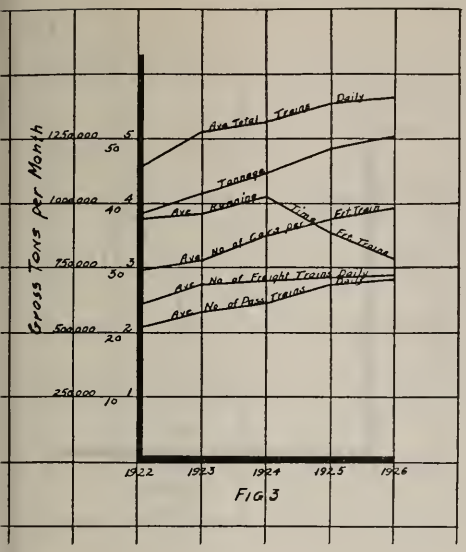

FIG 3

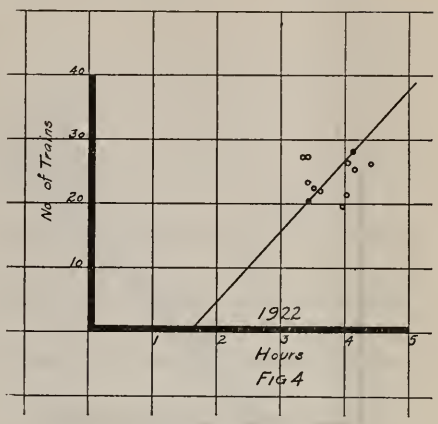

FIG 4

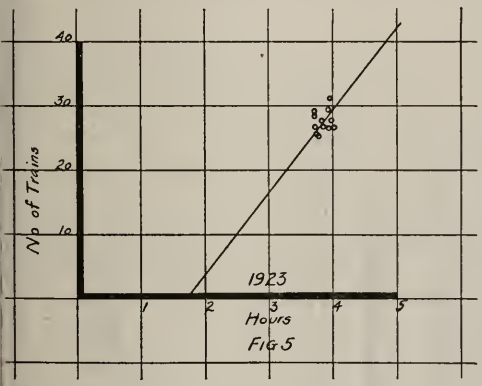

FIG 5

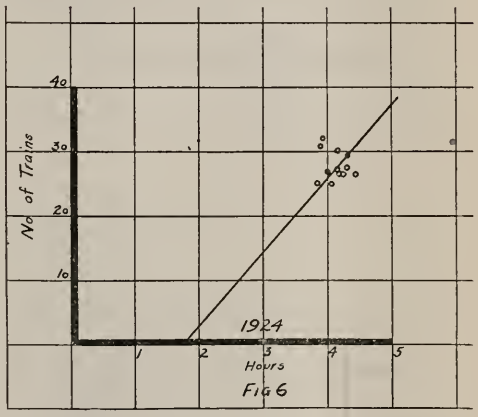

FIG 6

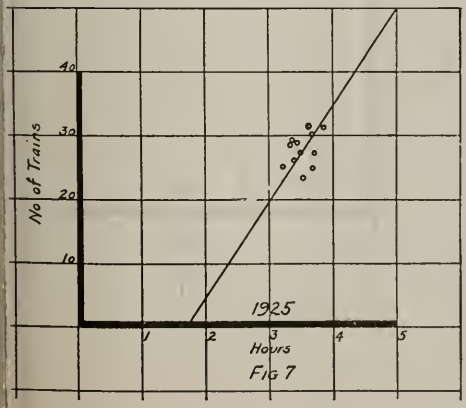

FIG 7

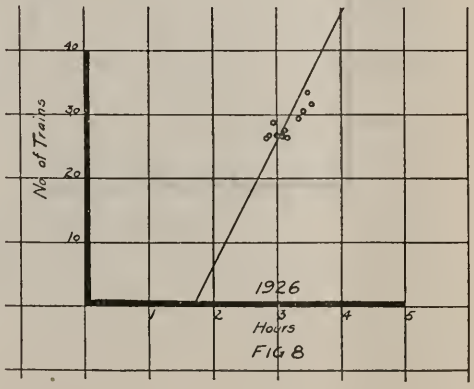

FIG 8

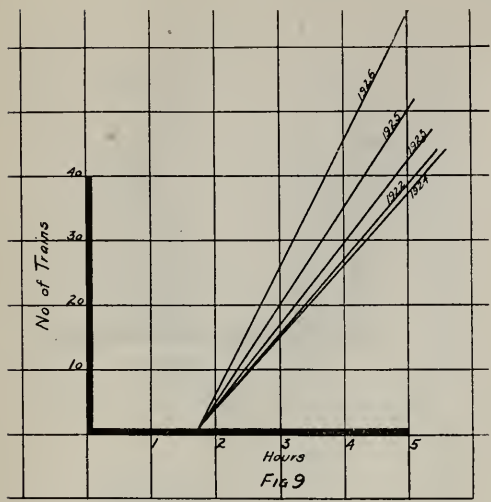

Fig 9

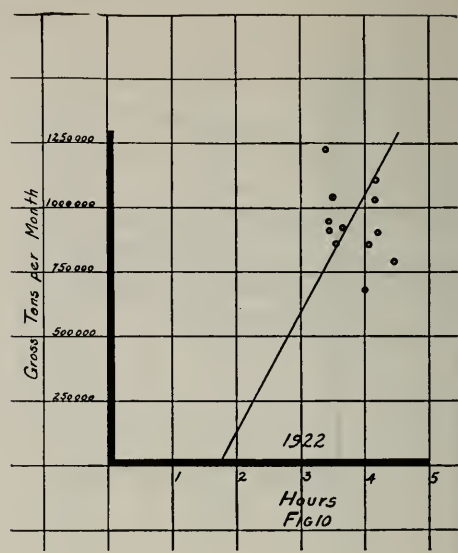

Fig 10

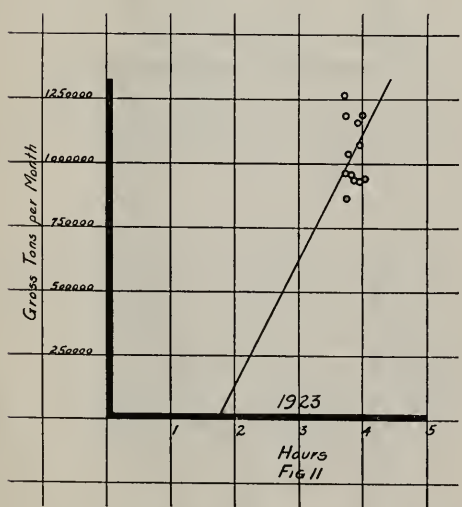

Fig 11

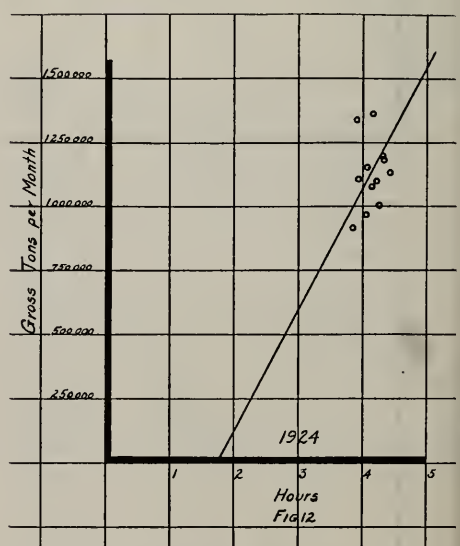

Fig 12

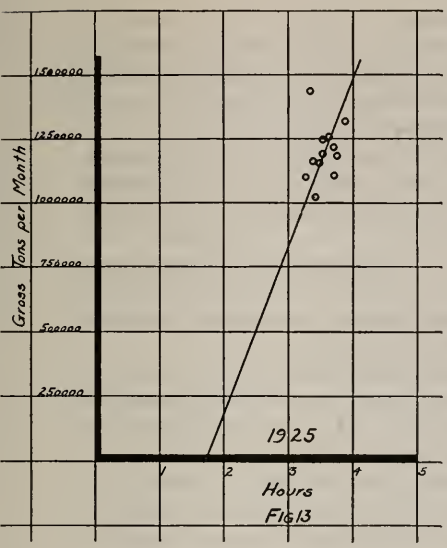

Fig 13

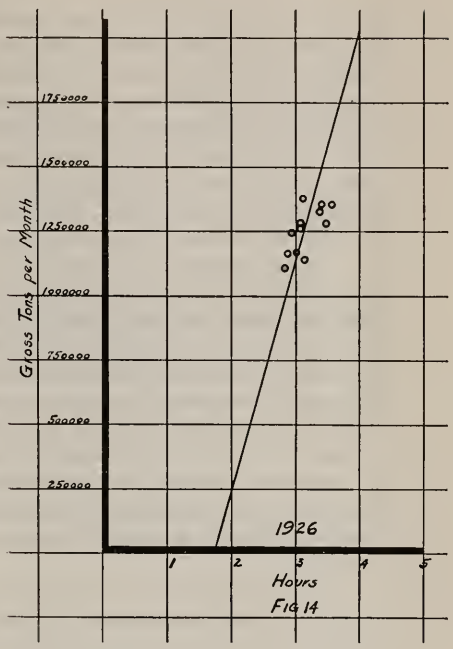

Fig 14

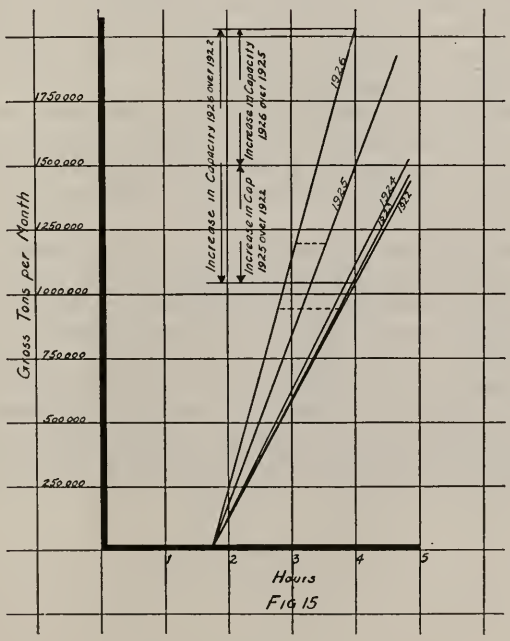

Fig 15

In Fig. 14 for an average running time of 4 hours there is shown an increase in capacity during 1925 over 1924 of 450,000 tons per month or approximately 43 per cent. In 1926 there is shown an increase in capacity over 1925 of 525,000 tons or approximately 35 per cent. The total increase in capacity in 1926 over 1922 is 975,000 tons or 93 per cent.

Fig. 14 shows that the time required to handle the 1922 tonnage during 1925 was reduced 39 minutes per train, while during 1926 it was reduced 1 hour per train over 1922. Also the time required to handle 1925 tonnage in 1926 was reduced 25 minutes.

On an average of 28 trains per day for 365 days per year this resulted in a saving during 1926 over 1922 of $28 \times 365 \times 1$ hr. or 10,220 train hours. For 1925 over 1922—$28 \times 365 \times 39$ min. or 6,643 train hours. For 1926 over 1925—$28 \times 365 \times 25$ min. or 4,259 train hours.

Fig. 15 shows that the performance during 1922, 1923 and 1924 was practically the same, the change in power, boiler pressure and boosters resulting in increased tonnage, and that there was a decided improvement during 1925 and a further improvement during 1926.

As stated before, aside from change in motive power in these years, the only other improvement made in facilities were the automatic signals which were not put in operation until 1926, and increase in weight of rail.

Upon investigation the Committee learned that beginning with 1924 more study and supervision was given to the operation of trains over this section of road. Efforts were made to reduce delays and to keep trains moving regularly and at a moderate and efficient speed. Every effort was made to reduce train stops. A reduction in 31 orders and an increase in 19 orders occurred. The results accomplished by this increase of supervision are shown by the performance of 1925.

During 1925 the management realized that in addition to the supervision given this section, additional steps must be taken in order to provide additional capacity for the increase in business. They decided on automatic signals and the effect of the automatic signal installation is shown by the performance of 1926.

All the improved operation and increased capacity obtained in 1926 can be laid to the installation of automatic signals, as there was no change in power used, sidings, grades, alinement, operators, or speed limit of trains in 1926 over 1925. However, there was a further reduction in 31 orders and increase in 19 orders. The principal reason for the saving in time with automatic signals was the reduction of the spacing between following trains. Before signals were installed the trains were operated by train orders and spaced station to station or an average of 5 miles. With automatic signals in use a train can follow another as soon as train has traveled an average distance of .79 miles.

Conclusions

(1) Increased supervision consisting of scientific study and thoughtful effort will increase the capacity of a railway.

(2) Installation of automatic block signals on a single-track railway will increase the capacity of the road, this increase varying with the length of the division on which installed and with the number of passenger trains operated.

(3) The above methods of increasing capacity being very economical ones, resulting in a saving in road time on present traffic and increased earnings as traffic increases.

(4) In addition to the increase in capacity, supervision and automatic signals provide other intangible benefits (See Bulletin 284, pages 745-746).

(5) A single-track railway, with proper supervision eliminating unnecessary delays and train stops, proper number and spacing of sidings, and proper signaling is a very efficient transportation machine, all of which have more intensive use than a double-track line handling traffic which does not reach its capacity.

Before second track is constructed careful study should be given to the practicability of increasing the capacity of the single track, either by increased supervision and study of operations, signals, or electrification, etc.

Appendix B

(3) DEVELOP AND REPORT UPON METHODS OR FORMULAS FOR SOLUTION OF SPECIAL PROBLEMS RELATING TO MORE ECONOMICAL AND EFFICIENT RAILWAY OPERATION

J. E. Teal, Chairman, Sub-Committee; M. F. Steinberger, B. Wheelwright, J. M. Farrin, H. T. Porter, J. M. Brown, C. C. Williams, S. B. Cooper, W. J. Cunningham, H. A. Osgood, V. I. Smart.

No new work was undertaken this year, all the efforts of the Sub-Committee being devoted to editing last year's report on cost of stopping trains for printing in Manual.

Appendix C

(4) BEGIN STUDY TO DETERMINE THE MOST ECONOMICAL MAKEUP OF TRACK TO CARRY VARIOUS TRAFFIC DENSITIES

No Sub-Committee was appointed to take up this work as it developed that similar assignment was being studied by Committee IV—Rail. It is therefore recommended that this subject be held in abeyance until Rail Committee has made its report and reliable data is available for conclusions.

Appendix D

(5) DEVELOP SUITABLE UNITS FOR OPERATING AND EQUIPMENT STATISTICS REQUIRED BY INTERSTATE COMMERCE COMMISSION TO BE USED IN COST COMPARISON OF TRANSPORTATION, EQUIPMENT AND ROADWAY MAINTENANCE WITH NECESSARY ADDITIONS THERETO

W. J. Cunningham, Chairman, Sub-Committee; L. E. Dale, H. C. Crowell, M. F. Mannion, G. D. Brooke, H. A. Osgood, F. H. McGuigan, L. E. Little, H. T. Porter, C. C. Williams, M. L. Byers.

No definite conclusions have been reached that could be added to last year's report. Recommended that subject be reassigned for further study.

Appendix E

(6) DETERMINE WHAT VOLUME OR OTHER CONDITION OF BUSINESS OR SERVICE JUSTIFIES A CHANGE FROM FLAT SWITCHING TO THE HUMP METHOD IN ANY GIVEN YARD

.J F. Pringle, Chairman, Sub-Committee; R. T. Scholes, B. J. Schwendt, L. S. Rose, L. E. Dale, J. M. Farrin, B. T. Anderson, Albert Hansen, G. F. Hand, J. L. White, A. C. Shields, M. F. Steinberger, T. C. Macnabb.

This year's work consisted in analyzing answers to questionnaire sent out the previous year. Fourteen railroads replied to the questionnaire, their answers being summarized as follows:

1. How many hump yards have you on your system?
One to sixteen.

2. How many of these yards are equipped with car retarders?
From the fourteen roads replying, only two have yards equipped with car retarders, but many others are investigating with a view to installation.

3. Generally speaking, what volume of business justifies hump yard operation compared with flat yards?
The volume of business which would justify hump yard operation as compared with flat switching is dependent on (a) number of classifications made; (b) ratio of total cuts to total cars handled.
Generally speaking, hump yard operation would be justified by 700 or more cars per day in and out with 15 or more classifications and a greater ratio of classification than 1:5, i.e., average of 20 cuts per 100 cars handled.

4. What train arrival frequency justifies hump yard?
The conditions as to volume and classification as given in answer to previous question rather than train frequency are the determining factors. When the class of business is such that it must be moved immediately and volume is greater than can be handled currently by flat switching the advantage of hump switching must be considered. In general train arrival frequency of one hour with 15 or more classifications will justify hump operation. Train frequency in flat yard operation interferes with switching and when this becomes acute the only alternative is hump operation.
Train frequency indicates facilities that should be installed to meet a given condition rather than necessity of hump operation.

5. How does number of classifications per train combined with train frequency arrival affect decision to use hump instead of flat yard switching?
The total volume per shift or per 24 hours, number of classifications to be made regularly and the ratio of cuts to total cars handled are the determining factors. Flat switching as compared with hump switching cannot be economically performed when the number of classifications exceed 20, as rehandling then becomes necessary.

6. How does mixed consist of trains and character of business affect economy of hump yards (several hump yards have been converted back to flat yards on account of business handled being unsuitable for hump yard operation)?

The more mixed the consist of trains and the greater the number of classifications or cuts to be made the greater the efficiency of the hump yard as compared with the flat yard. With 60 or more cuts per 100 cars hump operation is three times as fast as flat switching. Where the business to be handled is pre-classified and the only work is to add fillers to either end of the train there is no justification for hump switching. Where the business to be handled is both pre-classified and mixed a few tracks can always be provided for the handling of through trains by flat switching.

7. How does frequency of service to patrons affect the practical use of hump yards (in these days of competitive dispatch service it is often necessary to mix consist of freight trains and upon arrival at terminal make special deliveries)?

The flexibility of hump yard operation exceeds that of the flat yard operation and while the advantage of handling in time and economy depends upon the number of classification tracks available, with sufficient of these for the business offered cars can be classified and disposed of quicker by hump switching than by flat switching. For special delivery service short tracks can be provided.

8. How many cars per hour can be humped in a hump yard using one engine?

The number of cars which can be humped per hour using one engine both for bringing the cars from the receiving yard and shoving them over the hump depends upon

(a) Number of riders assigned and facilities provided for their return to the hump.
(b) Number of cars per train and number of cars per cut.
(c) Design of yard with special reference to speed with which cars will clear the lead.

and varies from 50 to 100 cars per hour. With two engines, one bringing cars from the receiving yard and the other pushing them over the hump and other conditions equal, this can be increased approximately 25 per cent, depending upon the distance from the receiving yard to the hump and the grades of the receiving yard.

9. Are more than two engines justifiable in a hump yard per shift?

In general more than two engines working on one hump are not economically justified but are necessary at times to clear the receiving yard and keep business moving currently.

10. What is the average maximum number of cars that can be humped per 8-hour shift and what number of engines are necessary?

With one engine working on a hump from 400 to 800 cars; with two or more engines 500 to 1000 cars.

11. In No. 10 do all engines utilized have full ground crew and if not state make up of each?

As a general rule engines working on hump have full ground crew, but in a number of cases conductor and one or two brakemen with car riders handle both engines.

12. What is the average maximum number of cars that can be classified in a flat yard per 8-hour shift and what number of engine hours necessary?

The number of cars which can be classified in a flat yard per 8-hour engine shift depends on number and length of classification tracks, number of classifications to be made and number of cars per cut as well as amount of interference on the lead. With 15 to 20 classifications and 2 cars per cut the number will vary from 125 to 300. Two or more engines will handle proportionately more if design of yard permits them to work without interference.

13. What per cent of cars are weighed on the average?

This is purely a local operation and no general conclusion can be drawn.

14. How much is your car damage per 1000 cars actually handled in yards for

(a) Hump yard with car riders.
(b) Hump yard with car retarders.
(c) Flat Yards.

The majority of roads reporting show less damage to cars in hump yards than in flat yards. Replies give insufficient data to enable comparison to be made with yards equipped with retarders.

One road states there should be less damage in hump yards with car riders and car retarders than in flat yards because the speed of each car is controlled, which is not the case in flat yard switching, and another road, "Whether or not hump switching is carried on with less damage to cars than flat switching depends largely on the attention given to the education of hump riders. It is our experience that where proper educational methods are adopted and every case promptly investigated and appropriate disciplinary action taken, hump switching can be performed with less damage to equipment than is usually sustained in flat switching."

15. How many cars per 8-hour shift per car rider are handled?

The number of cars per 8-hour shift per car rider varies with the length of classification yard, whether or not cars are ridden to coupling, facilities for return of riders, number of cars per cut and number engines assigned to the hump. The range is from 30 to 60 cars with 45 a fair average.

One road operating a large hump yard reports 46.6 as an average over an extended period.

16. How many cars per 8-hour shift per car inspector are handled in hump yards.

The number of cars per 8-hour shift per car inspector varies between 60 and 320 with 200 as a fair average.

17. How many cars per 8-hour shift per skateman are handled in both retarder equipped hump yards and car rider hump yards?

The majority of the roads do not use skatemen and those using them do not employ men on this work exclusively and have no figures to report. The only answer received giving number of cars per 8-hour shift per skateman shows 792. Other roads stated that they had done away with skatemen, having found that a rigid inspection of brake equipment renders them unnecessary.

18. How many men per track mile necessary to maintain

(a) Hump yard with car retarders.
(b) Hump yard with car riders.
(c) Flat Yards.

There are so few retarder equipped yards that no conclusion can be drawn with the data supplied. For other yards both flat and hump 0.5 men per mile track is the general average, and there is very little difference in the maintenance cost.

19. From actual statistical data derived from your operations, what is average cost per car handled in

(a) Hump yard retarder equipped.
(b) Hump yard with car riders.
(c) Flat Yard.

In arriving at these costs consider following expenses:

(a) Engine crews, including ground crews.
(b) Fuel, water, lubrication, etc., for engine, but no engine house expenses or repairs.
(c) All yard forces pertaining to particular yard operation.
(d) All office forces pertaining to particular yard operation.
(e) Electrical power.
(f) Maintenance expenses, labor and material for tracks, retarders, interlockers, etc.
(g) Give total number of cars handled per day in yard for which cost figures are given.

There are so few retarder equipped yards that the data submitted does not permit a conclusion to be drawn.

The answers submitted for other types of yard do not permit conclusion to be drawn as to comparative costs.

20. Is Classification Yard used as departure yard or is separate yard provided? If the latter describe briefly method of handling cars from classification track to departure yards.

The practice in regard to provision of advance or departure yard is about equally divided. Some of the roads replying have separate departure yards and the others dispatch their trains direct from the classification yard. Where departure yards are provided switch engines are used to shove or pull cars from the classification to the departure yard.

Recommended this subject be reassigned for further study and Committee's conclusions.

Appendix F

(7) STUDY PROBLEMS OF RAILWAY OPERATION AS AFFECTED BY THE INTRODUCTION OF MOTOR TRUCKS AND BUS LINES, WITH PARTICULAR REFERENCE TO ITS EFFECT UPON BRANCH OR FEEDER LINES

H. C. Crowell, Chairman, Sub-Committee; R. B. Abbott, G. E. Boyd, S. B. Cooper, G. F. Hand, E. E. Kimball, L. E. Little, L. H. Powell, Mott Sawyer, A. C. Shields, M. F. Steinberger, J. E. Teal, Barton Wheelwright.

Last year the Committee reported on the growth of highways and highway transportation and the effect of this growth on railroad traffic and revenue. The field of usefulness for motor coaches and trucks was pointed out. The advisability of making changes in operating rail lines where the traffic is light, through the use of these new transportation tools, was considered.

Since that report nothing has happened to indicate the advisability of changing any of the conclusions or recommendations. The growth of hard-surfaced roads and the increase in the number of motor vehicles of all varieties have continued unabated. The federal and state commissions continue to authorize the abandonment of unprofitable rail lines and railroad companies have made large increases in the size of bus and truck fleets.

The Society of Automotive Engineers, which includes many railroad officers in its membership, held its annual Transportation Meeting in October, 1927; the session pertaining to rail motor cars and motor coaches was attended by many railroad men, some of whom contributed papers bearing on the subject assigned to this Committee.

The tabulation of revenue passenger statistics for the years 1916 to 1925, published last year, is again presented, with additional information for the year 1926. The outstanding features in this report covering the Class I railroads in the United States are as follows:

Passengers carried reached its maximum in 1920 and has steadily declined to a minimum for the eleven-year period in 1926.

Passenger miles also reached its maximum in 1920 and has declined more or less continuously ever since, the figures for 1922 and 1926 being the lowest since 1916; the decline has not been as rapid as in the case of the number of passengers carried.

Average journey: a fairly steady increase since 1916, indicating that the loss in passengers carried has been largely, if not entirely, in the short-haul rider.

Passenger revenue reached its maximum with the increase in fares in 1920 and in 1926 had declined to the lowest figure since 1918.

REVENUE PASSENGER STATISTICS FOR CLASS I RAILROADS IN THE UNITED STATES

(Based on data compiled by the Bureau of Railway Economics)

	Item	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
(1)	Passengers carried, millions	1,006	1,067	1,085	1,178	1,235	1,035	967	987	933	888	862
(2)	Passenger miles, millions	34,586	39,477	42,677	46,358	46,849	37,313	35,470	37,957	36,091	35,950	35,478
(3)	Average journey, miles = (2) ÷ (1)	34.4	37.0	39.3	39.4	37.9	36.0	36.7	38.5	38.7	40.5	41.2
(4)	Passenger revenue (acct. 102), millions	707	825	1,032	1,178	1,287	1,152	1,074	1,146	1,075	1,056	1,042
(5)	Revenue per passenger mile, cents = (4) ÷ (2)	2.04	2.09	2.42	2.54	2.75	3.09	3.03	3.02	2.98	2.94	2.94
(6)	Passenger train miles, millions*	583	583	537	546	568	560	547	566	571	575	579
(7)	Passengers per train = (2) ÷ (6)	59.3	67.7	79.5	84.9	82.5	66.6	64.8	67.1	63.2	62.5	61.3
(8)	Passenger car miles, millions **	2,231	2,291	2,140	2,261	2,371	2,274	2,228	2,331	2,358	2,433	2,487
(9)	Passenger cars per train = (8) ÷ (6) **	3.83	3.93	3.99	4.14	4.17	4.06	4.07	4.12	4.13	4.23	4.30
(10)	Passengers per car = (2) ÷ (8)	15.5	17.2	19.9	20.5	19.8	16.4	15.9	16.3	15.3	14.8	14.3

* Includes proportion of mixed and special train miles.

** Includes mileage of sleeping, parlor and observation cars; dining, baggage and other passenger train cars omitted.

Revenue per passenger mile has declined since 1921, the first full year in which the increased fares were in effect; this is due to increase in excursion and other cut-rate fares and to the increasing ratio of commuters to total passengers.

Passenger train miles in 1926 reached its maximum since the slump following the war, the 1926 figure being the highest since 1917 when troops were being mobilized.

Passengers per train have been declining since the peak in 1919 when troops were being demobilized; the 1926 figure is the smallest since 1916.

Passenger car miles reached a maximum for all time in 1926; this shows that the decline in passengers, passenger miles and passenger revenue was not brought about by the failure of the railroads to give service.

Passengers per car in 1926 reached the lowest figure for any year in the period covered and possibly the lowest in history; when it is remembered that this figure, 14.3, is the average for all trains, including commutation service, in which cars occasionally carry 100 passengers, the seriousness of the situation is more apparent. This item is probably the best index of the relationship between service furnished by the railroads and the patronage of that service.

In the first nine months of 1927 the loss in passenger revenue (compared with the same period in the preceding year) was even greater than in the first nine months of 1926 and 1925. This loss was $46,000,000, or nearly half of the loss in total (passenger and freight) earnings; the percentage of loss was 5.8. For the first time in many years the travel in parlor and sleeping cars has declined, previous losses having been confined to the coaches where the length of journey is comparatively short.

This corroborates reports from independent motor coach operators that there has recently been a large increase in bus travel over comparatively long distances. Routes extending along the West Coast for more than a thousand miles have been in operation for several years, and plans for bus lines from Chicago to San Francisco, a distance of about 2200 miles, are reported under way.

Why are travelers using motor coaches more and more every year? At least three reasons may be given: (1) Economy, bus fares being usually well under railroad fares; (2) frequency of service; (3) convenience, the "store-door" principle having been applied to passenger service. For many of the railroad-coach passengers, the saving of 10 to 25 per cent of the highway time by use of rail transportation is of little importance, whereas the reduction in fare is important. Furthermore, a saving in time may result by using a bus that is ready to leave rather than by waiting several hours for the train. So far as comfort and enjoyment are concerned, much may be said on each side. The tendency is for greater comfort in motor coach designing, especially as regards the seating. In any case, it is thought that railroad operators should try to forget the old theory that novelty is the principal cause of bus-riding, at least for journeys exceeding

50 miles, and that after a few rides the novelty will disappear and the passenger will be back on the rails. Experience, especially in the middle and far west, indicates that the motor coach for comparatively long journeys is the popular conveyance for a certain class of travelers.

While the motor coach has drawn its patronage largely from the day-coach passengers, the recent installation of "super-de-luxe" motor coaches, with wider seats, better toilet facilities, buffet service, observation deck and more glass area in sides and rear, together with extra fares for the added comforts, indicates that strong efforts are being made to attract parlor car passengers. Where there is sufficient traffic to justify the expenditure, this situation is being met by faster rail schedules and more luxurious Pullman equipment.

As indicated in last year's report a railroad should give serious consideration to the use of rail motor cars or highway motor coaches wherever the use of one or both of these substitutes will result in larger net income or a reduction in loss. In some cases savings have been made by substituting rail motor cars for steam trains, and then further savings by the substitution of motor coaches for the rail motor cars. Emphasis is laid on the fact that the *maximum* economy should be obtained in one step; in other words, the saving resulting from the proposed substitution of rail motor cars for steam trains is no argument for the substitution unless it can be shown that no other transportation tool, such as a motor coach, will produce a greater saving.

A word of caution is offered those whose duty it is to determine the economy of providing some form of substitute service for unprofitable steam train operation: do not be misled by estimates of the cost of train operation that include high interest and depreciation charges. If the service is on a light traffic branch line where a small eight-wheel locomotive and one or two obsolete wooden coaches are used, the analyst should ascertain what use, if any, can be made of this released equipment if some substitute is provided. Often there is no place to use it, and with the continued abandonment of branch lines and the release of better equipment from the main line this condition will become more and more prevalent. In this case the determination of the cost of existing service, for the sole purpose of determining the economy of substituting some other form of service, should not include interest on the original cost or reproduction cost of equipment in in service, but merely interest on its resale or scrap value. Similarly, depreciation may have been accrued on the old equipment nearly or fully equal to its ledger value; to charge against the existing operation the full amount of depreciation for the class of equipment to which these old units belong is merely to mislead one's superiors as to the legitimate savings that are possible. On the other hand investment in rail cars and motor coaches means new money for which interest and depreciation may legitimately be charged. On lines where daily mileage is small these fixed overhead items represent a considerable portion of the total mileage cost and the theoretical savings may be only the result of inaccurately figured fixed charges. Regardless of the accountant's method of figuring costs for entirely different

purposes, the analyst should confine himself to a practical, common-sense viewpoint.

Recently there has been an effort to bring back the steam-propelled rail car that was used with more or less success a generation ago. Several manufacturers are working on cars of this type and in a year or two it may be possible to purchase a "gas" car that uses liquid fuel under a boiler rather than in an internal combustion engine. Theoretically a steam car has many points of advantage when compared with a car propelled by a gas-engine, and if the technical details that surround the design of burner, boiler and high-pressure steam engine can be successfully worked out it may be necessary to revise our estimates of the cost of rail motor car operation. Railroad operating officers should follow carefully these new experiments in rail car design.

In an appendix to this report there is a copy of a paper submitted by H. F. Fritch, Passenger Traffic Manager of the Boston & Maine Railroad, to the Transportation Meeting of the Society of Automotive Engineers on October 27, 1927, entitled: "Rail Car or Motor Coach—The Economic Field of Each." This paper contains so much material of value to railroad operators that it is reprinted here, by permission, in full.

Another railroad that has made good use of motor coaches in an entirely different field is the Baltimore & Ohio Railroad. A description of this road's train-side service in the New York district is included in the appendix.

The use of motor trucks by railroads and independent operators continues to increase. While this form of highway competition is frequently unfair the traffic diverted from the rail to the highway is usually short haul L.C.L. freight that added little if any to the net income of the rail carriers. On the other hand, the motor truck has proved to be a useful ally to the railroads in terminal and suburban work. The use of containers for L.C.L. freight is increasing and in the handling of these containers motor trucks and trailers are finding a new field for service. Many papers of interest to the railroad officer who operates or contemplates operating a fleet of trucks were presented at the Transportation Meeting of the Society of Automotive Engineers in Chicago on October 26, 1927; reports of this meeting, with copies of the papers, may be found in the Journal of the Society.

During the past year the Interstate Commerce Commission has completed its hearings on the interstate operation of motor vehicles and the effect of this operation on interstate railroads. It is thought that the Commission will make a report to Congress, either recommending specific legislation or stating merely its conclusion as to the necessity for regulation. Decisions of state courts, following the lead of the Supreme Court of Illinois, continue to uphold the right of the existing rail carrier to furnish such highway transportation as is needed. The recent decision of the Supreme Court of Appeals of West Virginia, by which rail carriers were given exclusive rights to furnish highway transportation over the protest of independent operators, indicates the trend of judicial thought along this

line. A complete story of motor transport legislation, past, present and future, may be found in papers presented at the Transportation Meeting of the Society of Automotive Engineers and reported in the Journal of that society.

This report is mainly an amplification of the report presented last year, and is submitted as a progress report. The effect of growth of highways, motor coaches and trucks on railway operation, especially the operation of light traffic branch lines, is serious and demands the careful attention of railway officers. The Committee, therefore, recommends that the subject be continued so that it may do its part in keeping the members of the Association informed of new developments.

Exhibit 1

RAIL CAR OR MOTOR COACH—THE ECONOMIC FIELD OF EACH

Presented at the Annual Transportation Meeting of the Society of Automotive Engineers, held in Chicago on October 27, 1927; reprinted by permission of the Society.

A railway has the right and the obligation to use the most efficient vehicle available to handle its traffic so long as it renders a reasonable service. This is regardless of whether the vehicle operates over its rails, over the highways or through the air.

The railway was for many years the only means of handling passengers and merchandise on land in volume with speed. The development of the internal-combustion engine and the simultaneous development of the highways has changed this condition. The private automobile has revolutionized the travel habit of people in the last 15 years and more especially in the last 10 years. The diversion of large volumes of traffic from the railway to the private automobile has forced the railways to find cheaper means of caring for their traffic on lines where the volume of business has fallen off. It is economically unsound for a railway to continue to operate with any other than the most efficient unit available. To do so is not for the good of the railway or the community; for the railway it means unnecessary operating expenses and to the public depleted service and eventually the unnecessary high operating cost will have to be paid by the public.

The internal-combustion engine has made possible two new units for handling the smaller volumes of traffic—the motor coach for highway use and the rail car for use on the railway right-of-way.

The contemporaneous development of these two vehicles results in interesting problems to determine which of the two may be used in each particular instance to the best advantage. There is a field for each and these fields seem to overlap. Each case under investigation must be decided on its own facts. It is impossible to lay down a hard and fast rule or formula by which all cases may be decided.

For the purposes of this paper, the transportation of passengers and of classes of goods ordinarily transported on passenger trains only will be considered. These are mail, newspapers, baggage, express and milk. No consideration is here given to the truck which may in some instances be a desirable unit to use along with the motor coach in substitute services to care for freight. I will point out some of the factors we have found in our experience on the Boston & Maine Railroad which should be considered in determining whether an operation should be converted to rail car or motor coach.

In studying this problem, one of the most important things is to be forward-looking and recognize that the automobile has changed travel habits,

has an appeal to personal convenience which is very powerful and that diminished service on branch lines facing such competition is very likely to result in further depletion of revenue. Furthermore, the advantages and limitations of both the rail car and motor coach must be squarely recognized and their effect not only upon oprating cost but upon traffic promotion reckoned with.

One of the fundamentals to determine is whether the continuation of a rail line is necessary or desirable for other traffic independent of the passenger requirements. If the passenger service alone must bear the burden of supporting the rail line where the traffic is light, the motor coach acquires quite an advantage over the rail car, as it may become possible to dispense with the privately supported rail line and use the publicly supported highway. On the other hand, if the maintenance of a rail line is desirable for the operation of freight service the use of a public highway as compared with the private way is of no great importance and the two vehicles must be compared on a cost basis disregarding maintenance or investment in way. It has been argued that the operation of motor coaches in place of rail service would endanger the continuance of a rail line and hasten the day of its abandonment.

This is not sound if there is any economic justification for the existence of the rail line at all. If, as is usually the case, there is a fairly substantial freight business on branch line and a light unprofitable passenger business, the reduction of the passenger loss as a result of going onto the highway would lessen rather than increase the danger of abandonment of the line.

Highways in the territory must be studied both with respect to their layout with reference to the communities to be served and also with respect to their character and capacity. It is frequent that the communities can be better served by highway than by rail because of the closer proximity of the highway to the settled sections or the ability to detour a motor coach through the settled sections, while the path of the railroad is expensive to change and is more limited as to curves and grades.

The character of highway surface and foundation is especially important in territory where the winter conditions are severe. The improvement of highways is one of the most remarkable things of our time of remarkable accomplishments. In the last few years great progress has been made in snow removal. It has been demonstrated that much more can be done along this line than was ever dreamt of a few years ago and that the effect on the highway surface is beneficial rather than harmful as had been predicted. In New England, as I suppose elsewhere, while this opening of the highways in winter has made it possible to operate our motor coaches, it has deprived our transportation lines of substantial amounts of revenue by making it possible for the automobile to stay in service.

Consideration should be given to the state of development of the motor coach and the rail car, having in mind its effect on obsolescence, cost of maintenance and operation and reliability of performance.

The motor coach for general highway use has been a comparatively recent development from the motor truck. There are large numbers of them in operation but I feel that they have not as yet reached the same degree of development as has the private automobile. Rail cars were being produced before the motor coach was being built for general highway use but the production of the former practically ceased about ten years ago, only to be resumed with increased activity since the world war. The real necessity for such a unit and the development of the gas-electric unit with throttle control of speed have been important factors in bringing this unit again into prominence. In the last four or five years great progress has been made but I would hesitate to say that its design has yet become stabilized. It appears to me that the tendency in rail car design since the motor coach has come into the field is toward larger and more powerful units than were first produced since its renaissance.

Neither the motor coach nor rail car have finished their period of development but good serviceable units of each kind are being produced and operated.

The ordinary maximum capacity of single deck motor coach today is twenty-nine. The capacity is limited to about this number in many states as a result of limitation on length. With a compartment in the rear with 19 sq. ft. of floor space for baggage, mail or express, the seating capacity becomes 24 with 5 supplementary taxi type folding seats in the baggage section.

Rail car capacity is not a matter subject to legislative regulation but is controlled only by restrictions dictated by good engineering and operating practice. Some rail cars have a capacity as low as 25 to 30 passengers. Others run to an over-all length of 73 feet, which if devoted entirely to passengers provides accommodations for as many as 86 passengers or 57 ft. of length for baggage or the like. Trailer cars are being operated up to about 73 ft. in length with seats for 90 passengers if there is no baggage space. Two-car motor rail car trains are now being commonly operated with the space in the train divided between passengers, mail and baggage, as the necessities of the particular operation require.

In studying any particular case, the possibility of redistributing traffic between other services available should first be gone into carefully. It is sometimes possible to rearrange traffic having in mind not only the passenger service but the freight service available, so that trips at first appearing to be beyond the range of rail car or motor coach capacity become possibilities for such substitution. Newspapers, express and milk are commodities which can sometimes be properly accommodated by other service without inconvenience to the public. These commodities can be much more readily accommodated on a rail car than on a motor coach. Ordinarily it is difficult to take care of much more than first-class mail and some baggage or newspapers on a motor coach. The Boston & Maine Transportation Company has in service motor coaches with baggage compartment in the rear, which are capable of carrying six medium sized trunks or 30 sacks of mail. As a practical matter, their capacity has been found to be ample in the services in which they are used. Then, too, it has been found practical in some instances, to reroute some of these commodities so that a reasonable service is retained but trips lightened so that they may be converted to rail car or motor coach. It has been surprising to find the number of trips which were originally out of the motor coach or rail car range of capacity, which by rerouting or transfer of commodities to other services, could be considered for substitute vehicles.

The final test in studying any case is of course the cost of providing the service with steam equipment, rail car or motor coach. Our experience with rail car costs as they have been obtained from other companies, is that they extend over a very wide range which is very disconcerting. It is difficult to obtain figures made up in a uniform manner and then, too, the costs vary so greatly, dependent upon the type of service and especially upon the length of run. Motor coach costs seem to have less variation as between carriers. We now find that the only satisfactory way for us to analyze each problem is to use costs based upon our own experience. On account of their importance and wide variation in different cases, we attempt to estimate the labor expense for the exact runs involved; similarly with respect to interest and depreciation. Fuel and maintenance are figured on a per mile basis, based on experience.

The motor coach has a big advantage over the rail car in wage costs. Motor coaches in such operations have a one-man crew with daily wages of something like $5.00. A rail car has a crew of at least two men whose minimum daily wages would amount to $14.04 and frequently a crew of three men with wages of $19.70. Furthermore, the restrictions as to hours and mileage of the rail car crew are such as to frequently increase these

minimum figures. These differences are very important where the volume of traffic is within the capacity of the motor coach; they are less important where the volume of traffic will fill a rail car unit.

On the Boston & Maine, after passing through a transition period, it has now become very largely a matter of volume of traffic to be handled which determines whether a rail car or a motor coach will be used in any case of substitution. The first experience of this road with these units was on a branch line of very light traffic density. A small rail motor car was substituted for steam service and the operating expenses substantially reduced. The mileage, however, was very low which resulted in the cost still being excessive. This rail car was then replaced with a motor coach and the cost still further reduced. An interesting development has since taken place. The distance from the town at the end of the branch line to the principal adjacent city by bus line following the branch line of the railroad or the parallel highway and by main line railroad is 13 miles; the main highway distance between the two is only eight miles. The substitute motor coach still furnishes some service parallel with the branch line but its principal activity is in carrying passengers over the short route to the neighboring city. This is of course an improvement in service to the community.

The Boston & Maine Railroad now has 24 rail cars in operation. Its Transportation Company has 72 motor coaches of which 22 may be said to be operating in substitution for rail service. On the other hand, it should be pointed out that there is some rail car mileage being operated, not in substitution for steam rail service but in addition to the former steam service in an effort to attract business by increasing the frequency of service. This type of rail car service is being operated on main lines and experience seems to indicate it is worth while. In one instance, the service on a branch line has been increased with rail car operation compared with what it was with steam operation, after some experimenting was done with motor coaches. Steam rail service was curtailed and supplemented by motor coach trips, the total number of trips being increased. Later, when a rail car became available, it was found that it was more efficient to provide all the service by rail car rather than part by steam and part by motor coach.

On another line 96 miles in length, between Worcester, Massachusetts, and Concord, New Hampshire, all the rail service is now provided by rail car units. The arrangement of trips with a minimum number of units made it impossible to make one main line connection, important for mail and passengers for a part of the line, so a motor coach was put in to cover this deficiency.

In New England, intrastate motor coach operations are very thoroughly regulated. This is as it should be, but in some instances the Boston & Maine has been unable to convince those having the licensing power that they should make substitutions of motor coaches for rail service where the railroad has felt it desirable. This has retarded the use of motor coaches to their full advantage. On the other hand, the substitution of rail cars for steam service lies entirely with railroad management and the Boston & Maine today is operating rail cars as it sees it, to substantially the greatest possible extent, having available only one and two-car rail units. It is now studying the possibilities with respect to heavier units capable of handling three cars all or part of the time.

I will briefly outline some of the typical rail car and motor coach operations on the Boston & Maine. Rail cars are now being operated at the rate of 970,000 train miles a year. The Worcester-Concord run previously referred to is an example of the most common use of these units. It is an out and out substitution of rail car units for steam trains, made because the volume of traffic was such that it could be handled by the rail car. This operation is a one hundred per cent change over, while on the other lines only part of the service has been changed.

On a 21-mile line between Plymouth and Lincoln, N. H., the two steam trips were changed over to rail car and because of the less expensive operation a third trip was added.

Main line service between Boston and Lawrence, 26 miles, was increased during the normal hours and two of the trips made by rail car with very short turn-around time.

Train service between Boston and Portland was considerably speeded up in part by eliminating stops from through trains. It was desirable to serve some of these places and feed into and from the express train at its midway stop. The rail car on account of its economy of operation made such a service feasible.

A suburban service is operated between Northampton and Springfield, Mass., 17 miles. There is a demand for a frequent service but the traffic is not heavy. It could be reasonably taken care of at least in part by motor coaches but a competitive condition with a trolley company makes it impractical to obtain license to operate, so a 73 ft. rail car making 5 round trips a day is being used.

Motor coaches covering 1,600,000 miles a year are being operated by the Boston & Maine Transportation Company. A substantial amount of this is paralleling the railway in competition with independent motor coaches operating without licenses on interstate routes. People are traveling on them because of the lower rates and the desire to use a motor coach. Highway operation by the railroad makes it possible for it to compete for these passengers and to meet rate cuts without changing the rate structure of the Railroad.

A motor coach line is operated 13 miles between Franklin and Bristol, N. H., in replacement of rail passenger service, except that express is handled in freight service. More frequent service is furnished by motor coach than was furnished by rail making connections with main line trains. This operation is in sparsely settled territory where the traffic is light and the rail losses substantial. The operation of a rail car would be an extravagance. At Bristol passengers and mail are delivered right in the center of the town instead of at the foot of a long, steep hill and at Franklin the school children are taken right to the school. Winter conditions are severe and the highway had never been kept open until the Transportation Company bought a tractor to demonstrate that it could be done. This type of operation to reduce rail operating losses is probably where the motor coach can be of the greatest benefit to the railroad.

Between Northampton and Greenfield, Mass., 19 miles, a motor coach line replaces some steam rail service and some stops on other trains which have been speeded up.

An independent trolley line connecting a beach with the railroad at Hampton, N. H., failed on account of lack of business, so the Transportation Company put in a coach line because of its value to the railroad as a feeder. The coach line just falls short of earning its full cost but it is a worthwhile operation, as it is an encouragement for people to travel by rail rather than by automobile. The railroad must do such things wherever it can.

The motor coach and rail car are both useful tools to be used in keeping the railroads on a sound operating basis and afford the means of furnishing organized transportation to communities which would otherwise cease to have it and a better service in many instances than would be possible with more expensive units.

Exhibit 2

THE BALTIMORE AND OHIO RAILROAD MOTOR COACH OPERATION IN NEW YORK

By M. F. Steinberger, Special Engineer

During the World War and for a number of years thereafter, the trains of the Baltimore and Ohio Railroad entering and leaving New York used the terminal facilities and station of the Pennsylvania Railroad. However, in the year 1926 it became necessary to find another method of continuing this service and arrangements were made with the Central Railroad of New Jersey for the use of both its station, track, and ferry facilities. Under the plan used by that and other roads whose rail lines terminate on the New Jersey shore it is necessary for passengers to make their own way from there to their destinations in Manhattan and New York, using, of course, the ferry boats of the roads upon which they traveled for the movement between the Jersey shore and Manhattan.

The management of the Baltimore and Ohio Railroad realized the desire of the public for a more convenient method of reaching their Manhattan destinations, and further having noted the increasing popularity of the motor vehicle, determined to make use of that means of transportation to give the service which it felt was desired.

Having reached that conclusion it was then necessary to develop the details involved in the successful inauguration of the plan, and studies were made to determine the following data:

First: The manner in which the operation should be conducted, namely: whether by the Baltimore and Ohio itself, by a subsidiary company, or by contract with an established operator.
Second: Where and how many stations should be established.
Third: The route or routes which should be followed.
Fourth: The number, type and character of motor coaches.
Fifth: The character of the stations, their fittings, etc.
Sixth: The ticketing and baggage arrangements.
Seventh: The manner in which the operation should be conducted at Jersey City, and other stations, so passengers could leave or board motor coaches with a minimum of delay and maximum ease.

In the consideration given the proper location of stations the Passenger Traffic Department, of course, had available information as to trend of travel and the location of strategic points by which the needs of travelers could best be met. Their studies, therefore, led to the choice of the following places in the business, hotel and theater districts, as the points at which passengers were to be received and delivered:

(a) Equitable Insurance Building (33rd Street and Seventh Avenue) in proximity to the Pennsylvania Hotel and Station.
(b) McAlpin Hotel.
(c) Waldorf-Astoria Hotel.
(d) Pershing Square (opposite Grand Central Station).
(e) Vanderbilt Hotel.
(f) Consolidated Ticket Office (57 Chambers Street).

After some experiment an additional stop was installed at Wanamaker's (4th Avenue and 9th Street). In addition to these stops, early in November further stations were established on Joralemon Street and at the St. George Hotel in Brooklyn.

Having decided that the proper method to be employed in transporting passengers between Jersey City and points east of the Hudson River was by motor coach, the next step was to determine upon the most desirable means of operating the motor coaches which would be employed. Three plans were considered, namely:

(1) Operation by the Baltimore and Ohio, under its own operating officers.
(2) Formation of a subsidiary company to perform the services.
(3) Negotiation of a contract with an experienced operator already functioning in New York.

The latter plan was the one adopted and the Fifth Avenue Coach Company chosen as the operating medium, and a contract entered into with it. Among the reasons for this action were the fact that they are the largest operators of motor coaches in New York, and have adequate garages, service stations, etc., and a trained personnel. Furthermore, they have so large a fleet that they are always in a position to supply surplus equipment to meet any emergency which may arise. It was obvious that with all these things in their favor, as well as the fact that the time to prepare for the installation was limited, such a company could establish the service with greater ease than the railroad could, as it would have had to build up from the bottom an operation with which its officers were less familiar than the coach company's staff.

Upon the conclusion of the preliminary negotiations covering the operations, and the decisions as to probable locations of the stations, studies were made to determine the routes to be used. Trial trips were made in motor cars and coaches over various suggested travel lanes; the time required and traffic interferences encountered carefully noted and studied. As a result of these studies the coaches move over streets on which they can travel with the least interference and quickest time to reach the scheduled stops and stations. They are as follows:

Liberty St. Route	*Twenty-Third St. Route*	*Brooklyn Route*
Ferry to foot of Liberty St.	Ferry to 23rd St. Terminal	Same as Liberty Street Route
West Street	Twenty-third Street	to Canal Street
Chambers Street	Seventh Avenue	Manhattan Bridge
Lafayette Street	34th Street	Jay Street
Fourth Avenue	Park Avenue to	Concord Street
Park Avenue to	Pershing Square Station on 42nd Street	Henry Street
Pershing Square Station on 42nd Street	with stops at	Joralemon Street
with stops at	Hotel McAlpin	to the
Consolidated Ticket Office on Chambers Street	Waldorf-Astoria Hotel	Station on that Street
Wanamakers	and Vanderbilt Hotel	and stopping at
and Vanderbilt Hotel		St. George Hotel
		en route.

As previously stated these routes were picked as the best, after numerous surveys were made. Of course it should be understood that in the event unforeseen traffic delays develop, the coach operators can exercise the right to deviate from the routes laid down, but are obliged to make the scheduled stops.

The question as to type and character of motor coaches then arose, and after careful consideration it was decided to place in the service what is known as the Y type coach, manufactured by the Yellow Coach and Truck Manufacturing Company of Chicago, they being of latest design and construction, giving convenient and comfortable accommodations with easy riding and smooth operation. It was felt that the affiliation of these manufacturers with the principal metropolitan coach lines of the country gave them experience which enable them to produce the coach best fitted to the needs of this particular and specialized service.

Orders were then placed for twelve such coaches; ten for service between Jersey City and Manhattan. Since that time the demands have been such as to make necessary the purchase of additional equipment, so that there are now in operation on the Jersey City-Manhattan-Brooklyn runs 22 motor coaches.

It will possibly be of some interest to give a brief description of the equipment used, and that is done in a general way without attempting to give too many technical details of construction.

In order to conform as nearly as possible to the Baltimore and Ohio train color scheme, the body of the coaches is painted Pullman green. The belt rail is royal blue with gilt letters reading "Baltimore and Ohio Train Connection." The window posts, hood top and wheel disks are of a light off-shade of green and the roof, fenders and hubs are black.

They are 28 feet 8 inches in length, the body proper being 22 feet 5 inches long, 7½ feet wide and 8 feet 1 inch high, and are of the de-luxe parlor car type.

The doors for passengers are of the sedan type and open outward. The door at the rear right side is for handling baggage in and out of a separate compartment which has been provided to take care of baggage requirements. In this compartment taxicab seats have also been provided for emergency use.

Only hand baggage is handled, there being no provision for trunks. A rail is also placed around the tops of coaches so that baggage can be handled there in case there is an overflow or some emergency requires the use of the taxicab seats in the rear compartment.

There are seats for twenty-two passengers, in addition to a seat for the driver and one for the coach attendant. These seats are arranged: ten double seats, five on each side and two single seats, one on each side beside the wheel housing.

The space over the wheel housing is occupied by a nickel-container designed as a receptacle for small packages. Its primary purpose, of course, is to eliminate the ordinary seat over the wheel housing which is uncomfortable, and was therefore not desired. In addition, as has been indicated

before, there are four auxiliary folding seats in the baggage compartment and the regular seats of the operator and an attendant. The seats are of the comfortable wicker chair type, having arm rests and divided backs, and double cushions provide proper resilience for smooth riding.

The frame work of the coach bodies is of second growth, thoroughly seasoned ash, all joints being treated with white lead or glue and either screwed or bolted. The roofs are grooved strips over ash car lines, overlapped by heavy duck dipped in white lead and painted, thus providing a waterproof roofing. All exterior panels have sheet aluminum covering so that wooden parts will not become exposed, and the entire cowl, windshield and door pillars are of unit steel construction.

The side panels on the interior are covered with fabric leather to match the seats, while the side post panels and roof headlining are of matched grain mahogany. Each side post is equipped with a plate-glass mirror. All hardware is finished in bright nickel and the floor covering is of battleship linoleum.

The windows are post-spaced with 44-inch centers, of plate glass, without frames, the glass slides being embedded in felt channels. They can be opened and shut by operating crank-type regulators. This arrangement applies to all side and rear windows, the rear windows being stationary. The side and rear window drapes slide on nickel rods.

Windshields are of plate glass framed with metal, having upper ventilating panels and electric windshield wipers. To supplement air circulation provided by windows and windshield are four roof ventilators in the sides and tops of cowl.

It was, of course, necessary that passengers be comfortable at all times, so that besides the means provided to keep them cool in summer, provision had to be made to keep them warm in winter. Therefore, a thorough system of heating was installed. Adjustable valves permit the exhaust gas to be carried through the thin-walled steel tubing that encircles both sides of the coach bodies, all exposed parts being covered with perforated steel guards; these guards are enameled to blend with the general interior colorings.

Special arrangements have been made for heating coaches electrically while standing for long periods at their terminals, before stations or in train shed at Jersey City. This was done to assure that coaches are comfortable when passengers are received after waits when engine was not running.

The interior illumination is furnished by ten opal glass dome lights of 21 C.P. and head lights are provided with ante-glare lenses, drum shaped and finished in nickel. This is important, as passengers are used to well lighted trains and the same degree of light had to be furnished on the coaches. Every effort is made to have passengers feel that the coach ride is but a continuation of train ride, with all its facilities. Other exterior lights are the front and rear markers, stop and combination tail and stop light.

The coaches are equipped with six cylinder sleeve valve engines, the valves having a bore of 4½ inches with a 5½ inch stroke. The upper and

lower crank cases are of aluminum. The crank shafts are 2¾ inches, properly balanced to eliminate distortion and providing a smooth, quiet and powerful engine. The transmission control mechanism, drive shafts, propellor shafts and rear axle are off-centered, permitting a low-level chassis, obviating aisle interference and affording more entrance space.

Steering is by means of a well-raked steering column actuating a cam and lever type gear. Quick and positive braking is secured by 4-wheel air brakes, in addition to which there is the usual hand or emergency brake. The air compressor is built as an integral part of the engine and the air is passed through an automatic control regulating the pressure in the storage tank, then back through an application to each wheel.

While it is appreciated that these descriptions make rather dry reading, it is felt necessary to indicate in not too great detail some of the salient points in connection with the construction of these coaches.

Having picked the location of the permanent stations, plans were then effectuated for equipping them. In order to put the service on as high a plane as possible, the appointments were made as complete as possible, and an air of richness as well as quiet dignity striven for. It was and is the constant aim to maintain the highest standards and prevent any blatant advertising or appearances in any direction. These stations are equipped with the best furniture possible to secure, comfortable chairs, splendid hangings and rugs and quiet and mellow lighting arrangements. All the necessary ticket racks, etc., were installed, but out of sight. Men's and women's rest rooms, maids and uniformed porters in addition to the ticketing forces were provided.

One of the questions which immediately arose when it was decided to use motor coaches was just how were passengers to be transferred between trains and coaches. It was apparent, of course, that they must be handled in motor coaches from Jersey City via ferry boats to Manhattan, and it immediately became apparent that they should be able to step directly from the trains to the motor coaches or vice versa. To accomplish that purpose, the Central Railroad of New Jersey assigned two tracks definitely for use of Baltimore and Ohio trains, and the tracks between were taken up and replaced by a broad roadway. This permits the motor coaches to be placed in position directly beside the trains so passengers can make the transfer with a minimum effort. The coaches are spotted beside the train in such positions as to require a minimum effort on part of passengers in passing to or from them.

Another difficulty presented itself through the fact that though the roadway constructed was wide enough for its purpose, the coaches could not be turned on it. To meet this difficulty a turntable was constructed at the end of the platform and satisfactorily solved the problem. It is, of course, manually operated, it being the duty of the coach operator and attendant to see that it is turned.

When this portion of the operating procedure had been solved consideration then had to be given the handling of the motor coaches on the ferry boats so that the comfort and safety of passengers would be abso-

lutely safeguarded. Arrangements were made so that unless it is absolutely impossible motor coaches be placed on the aprons so as to be out in the open. This is for the double purpose of giving those who elect to remain in the coaches for the boat trip a clear view of the New York skyline, and to assure light and fresher air than would be possible if the coaches were in the interior of the boats.

Further to insure safety and comfort, additional chocks were placed on the boats chained to their sides so that they could be placed under the wheels to prevent movement. Instructions were issued to operators to stop their engines immediately upon coming to rest on boats, place cars in the proper gear to further prevent movement, set their brakes, keep their tail lights burning, and they themselves instructed not to leave their places behind the wheel.

Other vehicles are not permitted within a certain distance, and the coaches are not permitted to exceed specified speeds in moving on or off the boats. No doors are permitted to be opened until the coaches are completely at rest. After that time passengers are informed that they may leave the coaches if they desire to move about the boat, but told at what time they are to be back in their seats.

Every effort is made to insure the comfort and convenience of passengers. For instance, here is the way they are handled when entering New York. The train conductor canvasses the train before reaching Philadelphia, to determine the number of New York passengers aboard. This information is telegraphed to New York so that sufficient motor coach equipment will be available. After leaving Philadelphia additional information is forwarded so that if any change in plans is necessary, such change can be made.

At Philadelphia a train attendant boards the train and interviews every New York passenger. He gets his New York destination from him and then tells him the proper coach route to use, whether the 23d Street route, Liberty Street route or Brooklyn route. He tags his baggage showing the proper coach and issues a stub which indicates the route and also shows the coach number. The latter procedure is to assure that the passenger and his baggage get on the same coach. Different color tags are used for each route, so that porters can properly identify and handle baggage. After the attendant has made his rounds, during course of which he proffers any other assistance possible, such as securing hotel accommodations, etc., the train porter gathers up the baggage and places it in the vestibules of cars, both Pullman and day coach.

Immediately the train comes to a stop the station porters take the baggage from the train and distribute it to the coaches shown on the baggage tags, the passengers proceeding direct to the motor coaches with no delay and no concern as to their belongings. Before boarding the coach they present the stub given by the train attendant to the coach attendant, which insures that they are on the proper motor coach. A force of station attendants is also present to assist the passengers if any are uncertain as to their proper movements.

The motor coaches then go to their places on ferry boats and on arrival on the Manhattan side continue on their routes, making the scheduled stops. At all hotel or other stops, other than the final station stops, the coach attendant handles their baggage from the coaches, placing it in the possession of passengers or hotel or other porters as they may desire. This service is, of course, performed without cost to the passenger, he being relieved of the necessity of tipping porters, paying taxi fares, etc., and, even in the event he is proceeding beyond the final coach stop and uses a taxi, his taxi charge is less.

Any passenger who for any reason desires to remain only for the day in New York may check his bags at one of the regular stations without charge and either call for it later or, if he is nearer to another one of our stations, when he desires to leave New York, he may telephone the station at which the baggage was left, giving the check number, and the baggage will be sent to Jersey City where he will find it beside his train on his arrival. In the case of a Pullman passenger, if he telephones his seat or berth number, he will find his baggage in his berth or beside his seat when he reaches the outbound train.

With respect to outbound passengers the general method is the same. They may check their baggage at stations at any time and it will be sent to their proper place on the train. They may purchase tickets at the regular stations and board motor coaches there, or they may board them at the other scheduled stops. If a passenger does board a motor coach at one of these points without having purchased a ticket, one dollar is collected from him by the coach attendant, a receipt being given therefor. This receipt is accepted by the train conductor as having a value of one dollar when applied to the purchase of a ticket to some point on the Baltimore and Ohio. This is to prevent any other than bona-fide passengers from riding the motor coaches.

One of the advantages of the system is the fact that passengers are to all intents and purposes on the train as soon as they board the coach. This is because trains always await the arrival of the coaches. However, in the event that an accident should occur, serious enough to cause material delay to the motor coach, the attendants have instructions to secure taxicabs from any source and forward passengers in them, giving proper authorization slips which are honored by ticket agents at designated point. This applies no matter if passengers are going to or from trains.

In order that the passengers may be thoroughly acquainted with the stops, the schedules have been prepared in such a way that both the place and time of all regular stops is shown. These schedules were prepared with great care and made conservatively so that there may be no question of their maintenance.

The Fifth Avenue Coach Company provided a new garage to take care of this equipment and carefully organized a trained corps of operators, attendants, supervisors, and despatchers. Before the operation was started these men were picked and classes were held at which they were taught and drilled in the details for which they were responsible. Dress rehearsals

were held, that is, coaches were run over the routes and all the details of operation were performed.

Such questions as the assignments of coaches and men to particular runs, tours of duty, inspections of coaches, oiling, greasing, repairs, etc., are functions performed under the contract by the Fifth Avenue Coach Company.

The establishment of the service herein described on August 29, 1926, was an innovation in terminal motor coach operation. It gives a pleasing service to patrons, removes the annoyances occasioned by the employment of porters and walks through passenger stations to taxis, eliminates the so frequent scramble for taxis, dissipates baggage worries, eliminates necessity for tips, and has many attractive features which appeal to the traveling public. The results obtained since its establishment give ample justification for the performance of such service in the manner described.

REPORT OF COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

F. R. Layng, *Chairman;*
F. L. Batchelder,
J. L. Campbell,
W. C. Coles,
Walter Constance,
C. E. Day,
F. B. Doolittle,
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P. E. Thian,
Walter Loring Webb,
W. H. Winterrowd,
J. C. Wrenshall,
F. E. Wynne,
M. A. Zook,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Continue the study of economics of railway location as affected by the introduction of electric locomotives (see Appendix A).

(2) Continue the study of relative merits of increasing tonnage by the reduction of ruling grades, or by the introduction of more powerful locomotives, including the consideration of momentum grades and the availability of the locomotive booster (see Appendix B).

(3) Continue the study of locomotive capacity, giving special attention to oil burning locomotives, collaborating with the appropriate Committee of Division V—Mechanical, American Railway Association (see Appendix C).

Action Recommended

1. That the progress report in Appendix A be received as information.
2. That the progress report in Appendix B be received as information.
3. That the data in Appendix C be received as information.

Recommendations for Future Work

1. Revision of the Manual.

2. Continue the study of economics of grade revision as affected by the introduction of electric locomotives, collaborating with Committee XVIII—Electricity.

3. Continue the study of the relative merits of grade lines lighter than 0.4 per cent.

4. Continue the study of the relative merits of increasing tonnage by the reduction of ruling grades or by the introduction of more powerful locomotives, including the consideration of momentum grades and the availability of the locomotive booster.

5. Continue the study of locomotive capacity, giving special attention to oil burning locomotives, collaborating with the appropriate committee of Division V—Mechanical, American Railway Association.

6. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY LOCATION,
F. R. LAYNG, *Chairman.*

Appendix A

(1) ECONOMICS OF RAILWAY LOCATION AS AFFECTED BY THE INTRODUCTION OF ELECTRIC LOCOMOTIVES

F. L. Batchelder, Chairman, Sub-Committee; F. E. Wynne, M. A. Zook, A. K. Shurtleff, Frank Lee, Fred Lavis, C. E. Day.

The assignment to this Sub-Committee is "Continue the study of economics of grade revision as affected by the introduction of electric locomotives." When the traffic on a portion of a railway fully equipped with the most modern steam locomotives and the using of other most modern facilities is approaching the limit of track capacity, one of the questions which naturally arises is "Shall the grade be revised or shall the existing line be electrified?" The answer cannot be given offhand but the problem is subject to an economic solution. This solution involves certain steps.

The grade revision must be designed and its cost calculated. The performance of steam locomotives on the revised grade must be determined and the best combination of train weights, speed and distribution of trains selected for the expected amount of traffic. The total cost of steam operation on the revised grade, including operating expenses, depreciation, taxes and interest on the new investment, may then be estimated.

On the other hand, the cost of electrification of the existing line must be calculated, the performance of electric locomotives determined and the best method selected for handling electrically the expected amount of traffic. The total cost as defined above of electric operation of the existing line may then be estimated and compared with that for steam operation of the revised line and a conclusion drawn on an economic basis.

The Manual gives a method for determining steam locomotive characteristics, and performance in service. The designers of electric locomotives are in a position to supply characteristic curves for any type and size of electric locomotive. From these characteristic curves, the detailed locomotive performance in service can be predicted with a high degree of accuracy. The Committee feels that a method of determining the service performance of the electric locomotive from its characteristic curves will be useful information for the Association to have in its records. The preparation of this information, together with typical examples of its application, is in progress.

Appendix B

(2) RELATIVE MERITS OF INCREASING TONNAGE BY THE REDUCTION OF RULING GRADES, OR BY THE INTRODUCTION OF MORE POWERFUL LOCOMOTIVES, INCLUDING CONSIDERATION OF MOMENTUM GRADES AND THE AVAILABILITY OF THE LOCOMOTIVE BOOSTER

W. L. R. Haines, Chairman, Sub-Committee; L. O. Sloggett, J. L. Campbell, C. P. Howard, C. E. Day, J. C. Wrenshall, F. M. Patterson, E. E. King.

LARGER LOCOMOTIVES VS. GRADE REDUCTIONS

This particular problem is but one sub-division of the general problem of making a dollar earn the most interest. To solve it the main elements to be considered are those of the general problem, viz.: Revenue, expense and investment.

Of course, were the earnings or gross revenues unaffected by the choice as between larger locomotives or lighter grades the elements of revenues might be eliminated from consideration. But in general it should be carefully considered as the capacity of the road for increased business may be seriously affected, for some years at least, by the present decision.

To What Extent Is the Problem an Alternative?

There may be presented the present alternative of doing several different things.

(1) Get more powerful engines;
(2) Reduce grades;
(3) Increase the number of main line tracks;
(4) Improve the signal system and yard facilities.

It is evident that any one, or a combination of these four alternatives, may be advisable in a given case, but confining our attention to the first two it is evident that they are not necessarily alternatives.

In certain cases both may be resorted to simultaneously to advantage. Thus it may pay to reduce the grades, assuming no increase in the power of locomotives. But a further computation may show that with the grades so reduced an additional saving may be affected by the use of heavier locomotives. Thus some very light grade railroads use powerful locomotives. It takes a powerful locomotive to handle one hundred loaded cars on a 0.3 per cent grade.

The most general form of the problem is probably—which expenditure, if either, should be made first; i. e., at the present time?

Reduction of grades will not necessarily prevent additional savings by the use of heavier locomotives, and the purchase of heavier locomotives will not necessarily prevent further economics by the reduction of grades.

(a) Advantages in the Use of Heavier Locomotives to Handle an Existing Traffic

(1) Their purchase is easily financed.

(2) Their total cost may be assumed as approximately the same as the cost of a greater number of smaller locomotives to do the same work. Similarly for repairs and renewals. There is no necessary increase in the permanent investment in equipment or in repairs and renewals of same. In the given case it may be possible to transfer the smaller locomotives to other lines or service where needed, or they may be gradually replaced by heavier locomotives as they wear out or become obsolete.

(3) In many cases it happens that the cost of heavier locomotives can be more accurately determined in advance than the cost of contemplated grade reductions.

(4) Usually it takes less time to purchase locomotives than to make grade revisions, and there is quicker return on investment.

It must be remembered that a comparison between antiquated existing locomotives and improved new locomotives is not a fair one. If the comparison is fairly made between modern locomotives of different tractive power, the total cost of the necessary tractive power, as well as the cost of repairs, renewals, fuel, water, etc., might be assumed to be approximately the same.

(b) Disadvantages of Heavier Locomotives to Handle an Existing Traffic

(1) Longer turntables, larger engine stalls.

(2) Heavier rails may be necessary.

(3) More ballast may be required, this in turn requiring the widening of the roadbed.

(4) The strengthening of bridges (steel as well as wood) may be required. As the strengthening of trestles usually requires shorter spans, more or heavier stringers, or both, with possibly more piles and posts to the bent, operating expenses (repairs) will be increased.

(5) The lengthening of passing and certain yard tracks. This disadvantage also applies to lengthening trains by reducing grades.

Items Nos. 1 to 4, inclusive, usually involve an increase in permanent investment, whereas an expense is involved for item No. 5; the total investment is not necessarily affected, as the total length of passing and yard tracks may be the same.

(b) Advantages of Grade Reduction vs. Heavier Locomotives to Handle a Given Traffic

As compared with an increase in the size of locomotives to effect the same reduction in the number of train miles, grade reduction has the following advantages:

(1) No increase in investment in equipment.

(2) Reduction in operating expenses due to saving in engine repairs,

and renewals, and in fuel and water, provided the rise and fall is also reduced as it usually is.

(3) A future possible saving, assuming that additional main tracks will be needed in the not distant future, and that it will later be necessary to reduce grades.

For, if second, third and fourth tracks are added on the present grades, and later it becomes necessary to reduce grades (probably involving also changes in line) the amount of work thrown away, and to be charged off the investment, will be much greater than if the grade had been reduced in the first place. It may be added, in this connection, that if grade reduction will be required in the future, the sooner it is done the less it will cost in many cases due to the increased number of facilities which will have to be replaced, increased cost of property, etc.

To effect a given reduction in the number of trains to handle a given traffic, grade reduction will increase the permanent capital investment in road and decrease investment in equipment and operating expenses as compared with substitution of more powerful locomotives. The saving in train wages would be approximately the same as for heavier locomotives, except for the differentials paid enginemen according to the age of the locomotives.

A moderate grade reduction will not save as much on certain classes of trains. They may be entirely unaffected by it. These are passenger trains, local and package freights, and certain fast freights in some cases.

Estimated cost of grade reduction should include the lengthening of passing tracks, and new bridges, when necessary, should be constructed so that they may be ultimately used for heavier power, at a minimum of additional expense.

If additional tracks will probably be needed, there is an advantage in grade reduction.

We must consider the permanency of the proposed route before going to heavy expenditures on a given line. Not only consider whether there should not be a new location abandoning parts or perhaps all of the new line, but in some cases it will be most important to consider the possibility of the acquisition by purchase of another line which would better serve the purpose. Should this be done, the savings from grade reduction might be much less than anticipated.

It should be borne in mind that the problem involved in a proposed grade reduction for a given division, or other length of line, is frequently one of considerable difficulty. For instance, it may appear today that a reduction to a given rate of grade could be most economical, and large expenditures made; later investigations might show that a different rate of grade, or an entirely different line, would have been most economical.

Best General Rule

Make a careful survey of present conditions, a forecast of future conditions and careful computations of the savings to be effected on each alternate plan to fit the present or future assumed conditions, and compare results. As there must necessarily be many important conditions that can-

not be accurately forecasted, a good real of judgment must be used. It is recommended, however, that the computations be made first and judgment exercised afterwards.

The whole computation, if the conditions can be correctly forecasted, is a matter of computing the greatest net earnings on the money to be permanently invested.

Any computations as to the savings between large and small locomotives, otherwise of identical design, in handling an existing traffic should primarily omit fuel savings except as a temporary matter, as it may be assumed that the fuel efficiency of the locomotive of moderate dimensions will generally be the same as for the larger locomotive—i. e., the amount of fuel consumed should be approximately proportional to the foot-pounds of work done or the tonnage hauled over the same line and grades. Some minor savings in fuel consumption by the use of larger locomotives may be effected by the elimination of congestion and delays with consequent saving of a portion of the fuel consumed while the engine is starting.

It is pointed out that if the decision is made that a grade revision is the answer to the problem the work should be done as promptly as possible for the reason that this country is expanding rapidly, construction costs are rising, and for the further reason that municipal and private improvements will make a proposed change more expensive if delayed. It should also be borne in mind that in some cases permanent improvements such as grade separation projects will be demanded on the existing line, which improvements may become entirely useless when the new grade line is constructed.

Appendix C

(3) LOCOMOTIVE CAPACITY, GIVING SPECIAL ATTENTION TO OIL BURNING LOCOMOTIVES, COLLABORATING WITH THE APPROPRIATE COMMITTEE OF DIVISION V—MECHANICAL, A.R.A.

W. H. Winterrowd, Chairman, Sub-Committee; Walter Constance, A. W. Galbreath, J. A. Noble, W. L. Webb, Fred Lavis.

The data in this Appendix was prepared by W. H. Winterrowd, a member of this Committee, and is submitted as information.

THE LOCOMOTIVE BOOSTER

By W. H. Winterrowd, Vice-President, Lima Locomotive Works, New York City

In the field of transportation, as in other lines of endeavor, the subject of economics is obviously of vital importance. Transportation, like other business, is founded for profit. Profits, being the difference between the amount which can be charged for the commodity and that which it costs to manufacture the same, allows very slight margins. Therefore, in any

business venture which requires production, it is essential that the costs be maintained at the lowest level, as a dollar saved in production is worth many times that of increased sales. Therefore, in the field of transportation it is essential that all expenses involved should be kept at a minimum. To do this requires a thorough analysis and consideration of all the details of operation, which eventually reverts to the statistics relative to operation. It is from the history of the past, as shown by these statistics, that the operation of the future and the necessary economies may be forecast.

From a perusal of the various expense items that go to make up the total operating expense, it will be observed that the majority of the expenses are directly affected by power. Thus power must receive primary consideration in any analysis in which the object is a reduction in the expense. From the 1925 operation it is found that of the total operating expenditures, 17.8 per cent was for maintenance of way and structures; 27.7 per cent for maintenance of equipment, and 50.5 per cent for conducting transportation, while 4 per cent was for the general expense.

Of the total expense for conducting transportation, it is found that approximately 60 per cent was expended for the direct expense. These direct expenses include enginehouse expense, fuel, wages, locomotive supplies, such as water, lubricants, etc., and train supplies. Approximately 45 per cent of the total transportation expense was expended in these items for road service alone. Under these conditions it becomes essential to provide ways and means for a reduction in these items, and as the greatest reduction can be obtained by decreasing all items, one naturally turns to the source from which these expenses arise. From a survey of these various expense items it will be observed that, with the exception of fuel, all expenses classed as direct expenses will remain practically constant for a train unit, regardless of the train load. Fuel, on the other hand, will vary with the train load, but not in the same ratio. Inasmuch as the majority of these expenses are constant for the train unit, it is essential that the maximum tonnage be handled per train unit, in order that the unit cost of production will be a minimum.

Another item of expenditure, which is inclusive in itself, but does fluctuate with the train unit, is the expenditure for maintenance of equipment, the largest expenditure being for locomotive maintenance. The maintenance of locomotives will depend on the class of service to which they are assigned, physical characteristics of the road and the design of the locomotive. It has been found from actual operation that with all conditions constant, but with a difference in the locomotive design, there is a considerable fluctuation in the maintenance cost per locomotive mile. On one road the following average maintenance costs were obtained for a number of locomotives of each class:

	Per Locomotive Mile
Mallet Type	$0.52
2-10-2 Type	.48
Light Mikado Type with the Booster	.27

On another road it was found that with two types of locomotives operating in fast service, there was a great variation in the maintenance cost. The average maintenance cost for the Pacific type locomotive was $0.19 per locomotive mile, while the cost of maintenance for the Consolidation type locomotive was $0.30 per locomotive mile. Thus, because of the wide variation in locomotive maintenance cost, on account of locomotive design, it becomes necessary to consider locomotive maintenance in conjunction with any analysis relative to a reduction in the unit cost of direct expense, for it may occur that the element of locomotive maintenance will be the deciding factor in determining the type of power to be used.

From an analysis of the transportation expense together with the locomotive maintenance expense, it is obvious that increasing the train load, thereby reducing the train unit, train miles, and locomotive miles, to do a given amount of work, offers the best field for the greatest economy. An increase in train load may be accomplished in either of two ways, or a combination thereof. The maximum grades may be reduced or the power of the locomotive may be increased, thus permitting of heavier loading per train unit. In any event, it always becomes a necessity to consider the type and power of the locomotive to be assigned, so as to obtain the maximum economy. With sufficient traffic available, to warrant increased power, so that greater train loads may be handled, the problem resolves itself into whether it would be more economical to obtain this increased power through the medium of a number of drivers, or whether the locomotive booster should be applied to some idle weight supporting wheel. On the other hand, because of the fact that locomotive maintenance is the minimum for locomotives having the least number of drivers, and increases with the number of drivers, would it not be more economical to utilize a locomotive with less number of drivers and the booster, in conjunction with grade reduction? These are problems, of course, which will vary with local conditions.

The locomotive booster is a simple, double-acting steam engine, having 10-inch by 12-inch cylinders. The power from these cylinders is transmitted through crankshaft and gears to the trailer wheels of the locomotive, or to the wheels of the front truck of the tender. The gear ratio between the booster and the trailer axle is 2.57. The control used in conjunction with the booster is of the semi-automatic type. In order that the booster may be put in use it is merely necessary that the main throttle of the locomotive be open and the booster latch on the reverse lever be lifted, so as to open the reverse lever pilot valve. The control valves then permit steam to enter the cylinders to idle the booster, so the booster gears idle and intermesh, open the main booster throttle and finally close the cylinder cocks, thus permitting the booster to deliver its maximum power.

At the present time there are four types of boosters being manufactured and in use. These types are the "C-2-L," "C-2-S," "D-1-L" and "D-1-S." Both of the "C-2" types are for locomotives of standard gage. The "C-2-L" booster has an average cutoff of 75 per cent stroke, while the "C-2-

S" booster has a cutoff of 50 per cent stroke. These two types of boosters are applicable to either the trailer or tender of the locomotive. The type "D" booster is manufactured with either a long or short cutoff, similar to the "C-2." The type "D" booster, however, is for use on roads where the track gage is less than standard.

Inasmuch as all track in this country is of standard gage, only the type "C-2" booster will be considered. From many tests on various railways and on our test plant it has been possible to obtain the drawbar pull, horsepower, mechanical efficiency and water rates for the booster.

It has been determined from the various tests that the "C-2-L" booster will deliver the drawbar pulls shown on Table I and derived from the following formula, in which the numerical factor takes into consideration the mean effective pressure, drop in pressure in booster inlet line and the mechanical efficiency of the booster.

$$D.B.P. = \frac{2475 \times P}{D},$$

when P = Boiler gage pressure
D = Diameter of trailer wheel.

In Table II is shown the drawbar pull for the "C-2-S" booster, derived from the following formula,

$$D.B.P. = \frac{2250 \times P}{D},$$

the numerical factor taking into consideration the same items mentioned for the "C-2-L."

From these tables it will be observed that with both the "C-2-L" and "C-2-S" boosters, the drawbar pull which may be developed depends on the pressure, diameter of trailer or tender wheels and the speed at which the locomotive is moving. It will be noted that as the speed increases the drawbar pull of the booster decreases. This, of course, is due to the increasing velocity of the steam flowing through the inlet steam line to the booster. The booster should never be operated at speeds where the revolutions per minute of the booster crankshaft is in excess of 400 r.p.m. Therefore, in these tables no drawbar pull is shown where the speed is greater than the recommended practice.

The power which may be delivered by a locomotive is a function of the capacity of the locomotive boiler. Inasmuch as the booster will add to the steam consumption of the main engine, which in turn will limit its effective use at certain speeds, the data as to the steam consumption of the booster is presented in Chart I. This data for saturated steam applying to the "C-2-L" booster shows the steam consumption for various piston speeds of the booster. Every nine degree rise in the superheat will decrease the steam consumption of the booster by 1 per cent. In the case of the "C-2-S" booster the decrease in cutoff from 75 per cent to 50 per cent reduces the steam consumption 20 per cent. Therefore, the steam consumption of the "C-2-S" booster is 20 per cent less than that shown on Chart I for the

Table I

STANDARD LONG CUT-OFF BOOSTER
DRAWBAR PULL CHART FOR 100 POUNDS BOILER PRESSURE

Speed	DIAMETER OF TRAILER OR TENDER WHEEL IN INCHES																		
M.P.H.	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
0	6880	6690	6510	6350	6190	6040	5890	5760	5630	5500	5380	5270	5160	5050	4950	4850	4760	4670	4580
5	5160	5060	4970	4880	4790	4710	4630	4550	4470	4400	4330	4260	4190	4120	4050	3990	3930	3870	3810
7	4480	4410	4350	4290	4230	4170	4110	4060	4000	3950	3900	3850	3800	3750	3700	3650	3600	3560	3520
9	3970	3920	3870	3820	3770	3720	3670	3620	3570	3530	3490	3450	3410	3370	3330	3290	3260	3230	3200
11	3560	3520	3480	3440	3400	3360	3320	3280	3240	3200	3160	3130	3100	3070	3040	3010	2980	2950	2920
13	3160	3140	3120	3100	3080	3060	3030	3000	2970	2940	2910	2880	2850	2820	2790	2770	2750	2730	2710
15	2770	2770	2770	2770	2760	2750	2740	2720	2700	2680	2660	2640	2620	2600	2580	2560	2540	2520	2500
17	—	2410	2420	2430	2440	2440	2440	2440	2430	2420	2410	2400	2390	2380	2370	2360	2350	2340	2330
19	—	—	—	—	—	2150	2160	2170	2180	2180	2180	2180	2180	2180	2180	2180	2170	2160	2150
21	—	—	—	—	—	—	—	—	—	—	1940	1950	1960	1970	1980	1980	1980	1980	1980
23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1780	1790	1790	1790	1790
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1630

$$\text{Booster Drawbar Pull at Start} = \frac{2475 \times \text{Boiler Pressure}}{\text{Diameter of Wheel}}$$

EXAMPLE Find Booster drawbar pull at 5 M. P. H. for a 43" Wheel and 200 lbs. B.P.

SOLUTION D. B. P. = 4550 × 2 = 9,100 lbs.

TABLE II

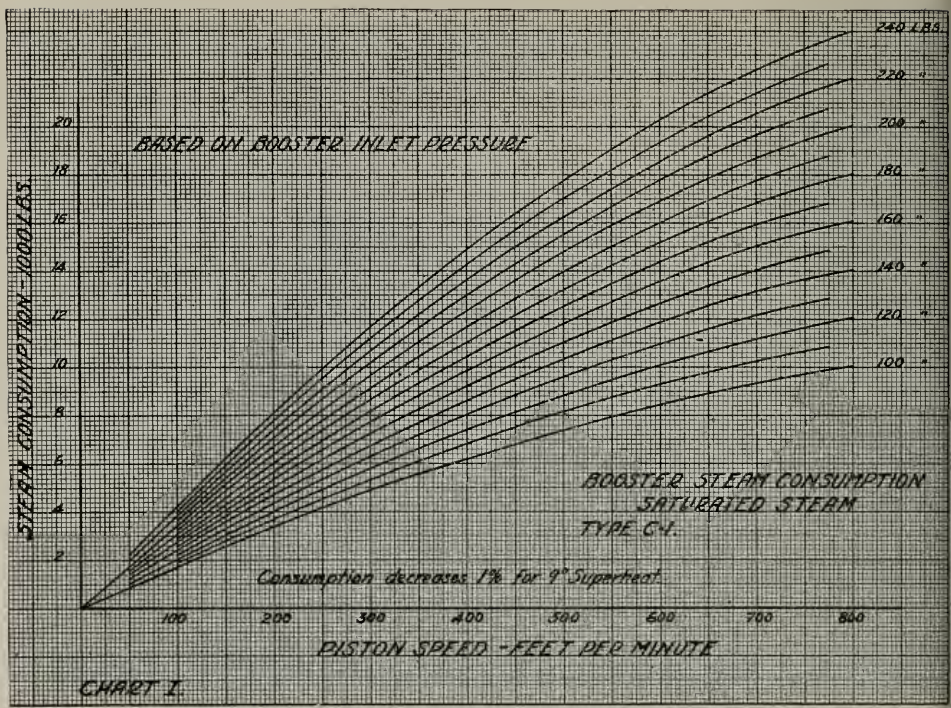
STANDARD SHORT CUT-OFF BOOSTER
DRAWBAR PULL CHART FOR 100 POUNDS BOILER PRESSURE

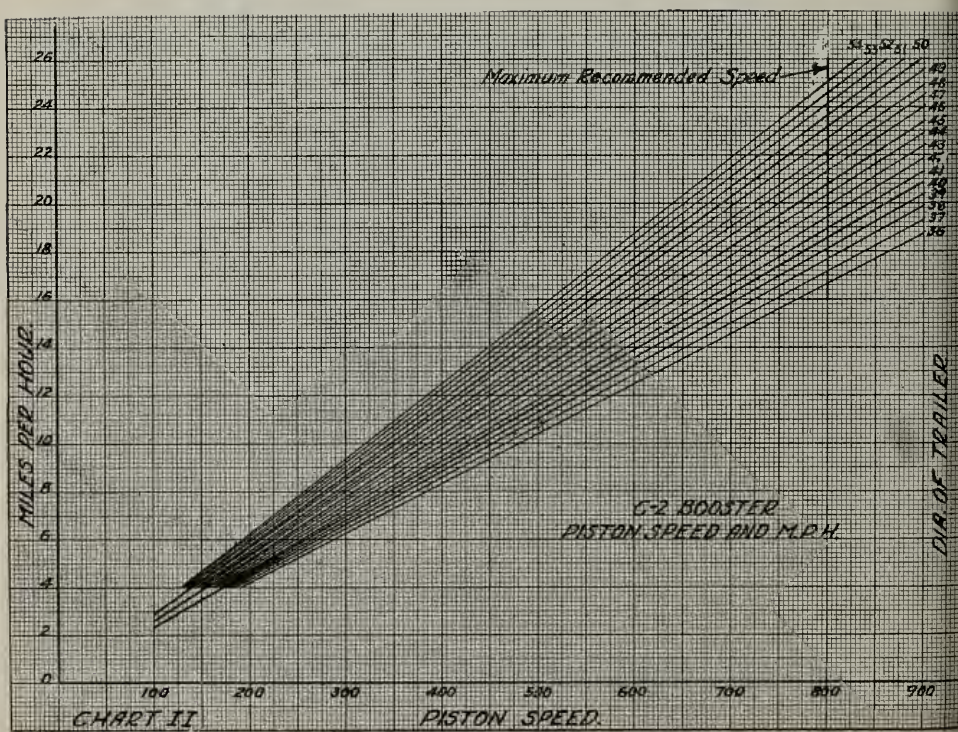
Speed	DIAMETER OF TRAILER OR TENDER WHEEL IN INCHES																		
M.P.H.	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
0	6250	6080.	5920	5770	5630	5490	5360	5230	5110	5000	4890	4790	4690	4590	4500	4410	4330	4250	4170
5	4690	4600	4520	4440	4360	4280	4210	4140	4070	4000	3940	3880	3820	3760	3700	3640	3680	3520	3470
7	4080	4020	3960	3910	3850	3790	3740	3690	3640	3590	3550	3500	3460	3410	3370	3320	3280	3240	3200
9	3610	3570	3520	3480	3430	3390	3340	3290	3250	3210	3170	3140	3100	3070	3030	3000	2970	2940	2910
11	3260	3220	3180	3140	3100	3070	3030	2990	2050	2920	2880	2850	2820	2790	2760	2740	2720	2690	2560
13	2920	2900	2880	2860	2840	2810	2780	2750	2720	2690	2660	2630	2600	2570	2550	2530	2510	2490	2470
15	2580	2580	2580	2570	2560	2540	2520	2500	2480	2460	2440	2420	2400	2380	2360	2340	2320	2300	2280
17	——	2260	2270	2270	2280	2280	2270	2270	2260	2250	2240	2220	2200	2190	2180	2170	2160	2150	2140
19	——	——	——	——	——	2020	2030	2040	2040	2030	2030	2030	2030	2020	2020	2020	2010	2000	1990
21	——	——	——	——	——	——	——	——	——	——	1830	1830	1840	1840	1850	1840	1840	1840	1840
23	——	——	——	——	——	——	——	——	——	——	——	——	——	——	1670	1670	1670	1670	1670
25	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	1530

Booster Drawbar Pull at Start = $\frac{2250 \times \text{Boiler Pressure}}{\text{Diameter of Wheel}}$

EXAMPLE Find Booster drawbar pull at 5 M. P. H. for a 43" Wheel and 200 lbs. B.P.

SOLUTION D. B. P. = 4140 × .2 = 8,280 lbs.


BASED ON BOOSTER INLET PRESSURE
STEAM CONSUMPTION—1000 LBS
240 LBS.
220 "
200 "
180 "
160 "
140 "
120 "
100 "
BOOSTER STEAM CONSUMPTION
SATURATED STEAM
TYPE C-1.
Consumption decreases 1% for 9° Superheat.
PISTON SPEED - FEET PER MINUTE
CHART I.


Maximum Recommended Speed
MILES PER HOUR
DIA. OF TRAILER
C-2 BOOSTER
PISTON SPEED AND M.P.H.
CHART II
PISTON SPEED.

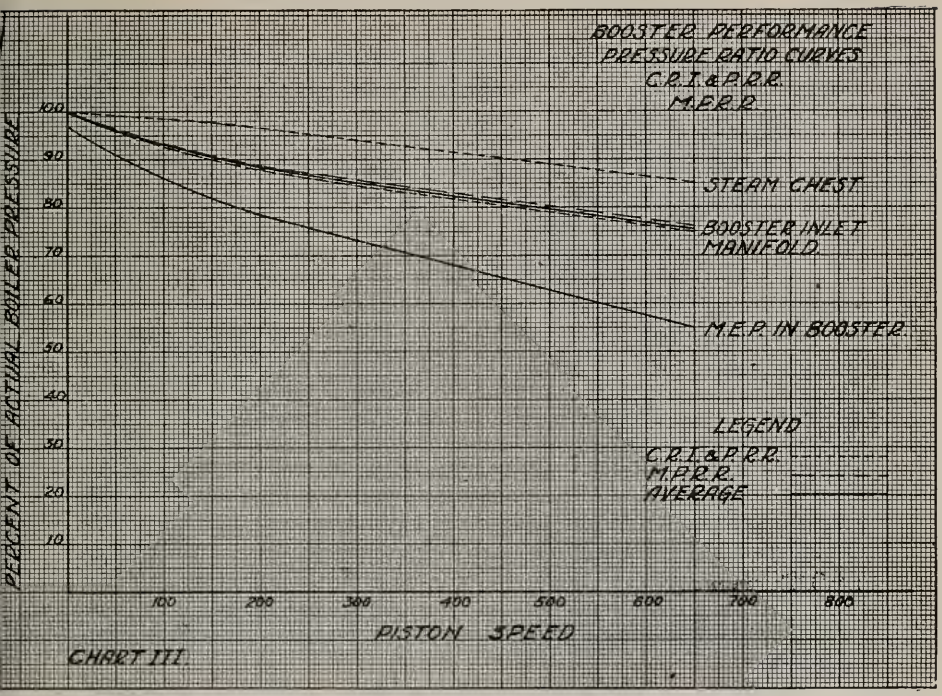


CHART III.

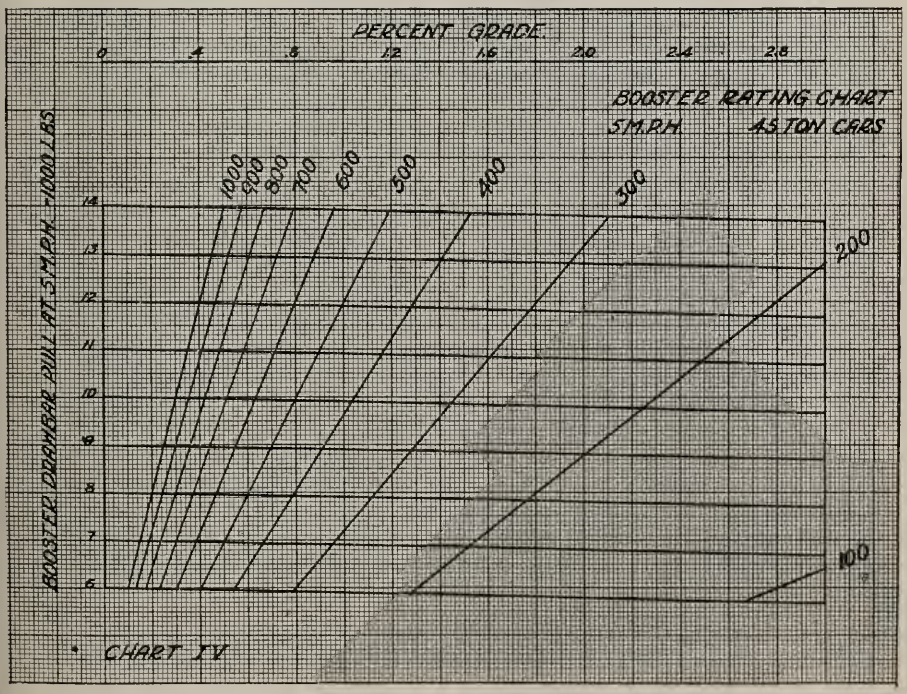


CHART IV

"C-2-L" booster. In order that the steam consumption of either type of booster may be obtained, it is necessary to know the piston speed of the booster and the pressure in the booster inlet manifold for the desired speed. On Chart II is presented the piston speed of the booster in feet per minute in relation to the speed of the locomotive in miles per hour for various diameter of trailer or tender wheels. On Chart III is presented the percentage of boiler pressure obtainable at the booster inlet manifold for various booster piston speeds. With the data contained in these three charts it is possible to obtain the steam consumption of the booster for various speeds and trailer or tender wheel diameters.

The power which is developed by the booster as supplemental power for the main engine makes it possible to start and haul greater train loads on any grade. On Chart IV are shown the additional tonnage in 45-ton cars which may be handled at a speed of 5 m.p.h., on all grades up to 3 per cent. This chart may be used in conjunction with Tables I and II for determining the tonnage which the booster will handle in addition to that hauled by the main locomotive. In a particular case determine from Table I or II the drawbar pull which the booster will deliver at 5 m.p.h., then on Chart IV lay in this drawbar pull line parallel to the line shown for the drawbar pull on the side of the chart. At the point where the drawbar pull line intersects the vertical grade line, lay in a diagonal line similar to the ones shown for each 100 tons. In this manner the tonnage which the booster will handle on the maximum grade at 5 m.p.h. may be obtained.

The booster is one means of obtaining greater power per locomotive unit, thereby making it possible to increase train loads and thus decrease unit costs. The other means of obtaining greater power is through the medium of additional drivers, which of necessity causes an increase in locomotive weights. Because the booster makes it possible to handle an increased train load it will sometimes be found that a locomotive with a less number of drivers and the booster may be used in place of the more powerful locomotive. This reduction in the number of drivers will show substantial economies in locomotive maintenance, while the use of the booster will increase locomotive maintenance by only $0.005 per locomotive mile, a very small proportion of the locomotive maintenance expense for any type of engine.

On one road which enjoys a profitable business of the preferred class, which makes it imperative that the service be prompt and fast, it was found after several years that the business as delivered by the connecting lines could not be handled in one train unit with one Pacific type locomotive, as was previously the case. It was, therefore, necessary to either double-head or use heavier engines to handle the business in one train unit. The road naturally chose the last mentioned method and substituted a Consolidation type locomotive for the Pacific type which was in use. After several years of operation with the 2-8-0 type locomotive a study of the operation was made, which revealed that the cost of locomotive maintenance with the Consolidation type was $0.30 per locomotive mile, while with the Pacific

type it was $0.19. A study of the local conditions relative to the use of a booster on the Pacific type showed that train loads were based entirely on starting on the maximum grade. The supplemental power of the booster as applied to the Pacific type locomotive gave the same starting power as the Consolidation type locomotive. At a speed of 8 m.p.h. there was a slight deficiency in power with the booster-equipped Pacific type locomotive. At a speed of 25 m.p.h. the Pacific type locomotive developed greater power than the Consolidation. The booster was therefore applied to the Pacific type locomotive. The service rendered was the same with both the Consolidation and booster-equipped Pacific, but in using the Pacific type equipped with the booster the maintenance cost of the locomotives for this service was reduced from $0.30 to $0.195 per locomotive mile, a saving of $0.105 per locomotive mile attributable to the booster.

In another instance the traffic on one sub-division of a railway had increased to such an extent that the trains being brought from the first division into the terminal could not be carried over the second division in one unit, and therefore a greater number of train units were necessary for this division than for the first division. It was realized that a locomotive with greater power would handle greater tonnage per train unit and thus reduce the number of necessary train and locomotive miles. A study was made to determine whether or not to use a 2-10-2 type locomotive or equip the existing Mikado locomotive with the booster. It was found from this study that whereas the existing operation was costing $0.734 per 1,000 gross ton miles, the estimated cost of operation with a 2-10-2 type locomotive handling 500 additional tons per train unit would be $0.642 per 1,000 g.t.m. and with the present Mikado and booster, capable of handling 400 additional tons per train unit, the cost would be $0.611 per 1,000 g.t.m. This road therefore decided to apply boosters to the existing power. After the boosters were in operation for a sufficient period of time a check of the operation showed that while the operation without boosters cost $0.734 per 1,000 g.t.m. the operation with boosters during a similar period had cost $0.605 per 1,000 g.t.m. Thus the increased train load made possible by the booster actually caused a reduction of $0.129 per 1,000 g.t.m., which is equivalent to a reduction of 17.6 per cent.

Thus two roads have made studies of their local conditions and decided on the use of the locomotive booster because of the economic benefits which would result from their operation. One road obtained an economy in maintenance expense because of using a booster-equipped locomotive of different design in the same class of service. The other road obtained economic benefits because of the increased load per train unit.

It is operations such as these that have made it possible to place over 3000 boosters on 68 railways in the United States and foreign countries during the past six years.

REPORT OF COMMITTEE XXII—ECONOMICS OF RAILWAY LABOR

A. N. Reece, *Chairman;*
G. M. O'Rourke,
C. C. Cook,
J. C. Patterson,
Lem Adams,
J. A. Heaman,
W. S. Bennett,
H. M. Stout,
Cale Wamsley,
*J. D. Keiley,
H. M. Church,
C. S. Joseph,
J. R. Caswell,
F. S. Schwinn,
F. M. Thomson, *Vice-Chairman;*
J. M. Sills,
E. T. Howson,
R. L. Schmid,
C. A. Ashbaugh,
Wm. Carpenter,
A. E. Botts,
John Evans,
J. B. Mabile,
J. F. Dobson,
W. A. Murray,
H. A. Cassil,
F. B. Doolittle,
W. S. Burnett,

Committee.

*Died July 8, 1927.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith reports covering the following subjects:

No revision of the Manual is recommended.

(1) The extent to which it is practicable to stabilize employment in the Maintenance of Way Department in the interest of efficiency and the necessary measures to accomplish it (Appendix A).

(2) Economy in the use of labor-saving devices (Appendix B).

(3) Standardization of motor car parts (Appendix C).

(4) Equating track values for labor distribution (Appendix D).

Action Recommended

(1) That the work of the Sub-Committee be accepted as final and Sub-Committee be excused.

(2) That the work of the Sub-Committee be continued and consideration be given to reducing the number of labor-saving devices to be studied each year to be reduced not to exceed two items in order to allow intensive study of the devices assigned.

(3) That the report of the Sub-Committee be accepted as information.

Recommendations for Future Work

(1) Revision of the Manual.

(2) Continue the study of methods for securing greater efficiency and economy by the use of labor-saving devices in railway track maintenance.

(3) Continue the study of standardization of parts and accessories for railway maintenance motor cars.

(4) Continue the study of equating track values for labor distribution.

(5) Economic ratio of supervision to labor.

(6) Practical education and training of the individual workman in his assigned duties as a means of securing an increased output of better quality with less effort and fewer accidents.

(7) Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY LABOR,
A. N. REECE, *Chairman.*

Appendix A

(1) THE EXTENT TO WHICH IT IS PRACTICABLE TO STABILIZE EMPLOYMENT IN THE MAINTENANCE OF WAY DEPARTMENT AND THE NECESSARY MEASURES TO ACCOMPLISH IT

Lem Adams, Chairman, Sub-Committee; W. S. Bennett, H. M. Stout, Cale Wamsley, J. M. Sills, E. T. Howson, R. L. Schmid, C. A. Ashbaugh, C. C. Cook, Wm. Carpenter, A. E. Botts.

After further and extensive study of our subject during the present year we find no changes to be made in the conclusions as adopted for publication in the Manual last year, but, on the contrary, our investigations have added decided strength to the conclusions heretofore reached.

Therefore, in order to bring this subject more forcibly before our membership, we submit the following resumè of reports that have been submitted over the past three years:

No single factor exerts a more direct influence on the efficiency in handling maintenance of way work than its orderly prosecution throughout the year. It is, therefore, essential that a budget be prepared and approved, based upon a program outlined sufficiently in advance of the budget, that will enable the materials to be assembled and forces organized for the proper execution of the year's work, and still more important, that all officers adhere as strictly to this program as possible in order to secure its full effectiveness.

It has long been recognized in industry that uniformity in volume of work and continuity in operations are essential to the maximum efficiency, and that as these decrease, the cost of work increases. The general practice on many of our American railways of making maintenance allowance from month to month to conform to the wide fluctuations in earnings exerts a very heavy toll on maintenance of way operations, by added costs due to decreased efficiency in the force employed. We believe that if the losses which result from this practice were more fully realized by all concerned, this policy would be discontinued. This method of parceling out funds for maintenance of way expenditures makes it necessary to do the max-

imum amount of work when the traffic is heaviest, regardless of the fact that, at this period, men are more difficult to secure, wages highest and a poor quality of work generally obtained at a very high unit cost. This condition is not necessary to the financial security of the average American railway, and large economies can be effected if they will forego a small adverse showing in earnings for certain months in order to secure an increased net earning for the entire year.

In its 1926 report, your Committee made three sub-divisions of this subject:

(1) The equalization of expenses.
(2) The determination of the extent to which the maintenance of uniform forces is justified.
(3) The effect of stabilization of employment on uniform purchases of materials and on their costs.

THE EQUALIZATION OF EXPENSES

The Interstate Commerce Commission made an order, effective July 1st, 1914, which authorized the railways to equalize their monthly charges for the repair of fixed improvements by including in appropriate primary accounts a uniform proportion of the amount of authorized estimates of such expenses for the year.

By further order of the Commission on June 2, 1924, the order was revised to permit the equalization of authorized estimates for maintenance of fixed improvements by dividing such authorized estimates into equal parts, corresponding to the number of months remaining in the year after the adoption of the maintenance program.

The order further specifies Account 280, "Equalization Way and Structures," for showing each month the adjustment necessary between actual expenditures included in the other primary accounts and the equal monthly proportion of the estimated or authorized maintenance expense for the period.

The authorization by the Commission of such optional procedure on the part of carriers is a recognition of the principles of freedom of action which should rest with the railways, and might be construed as a suggestion of the opportunity provided for efficient practice.

The opinion has been advanced that the equalization of expenses is unsound from an accounting standpoint, i. e., that "The function of accounts is to show facts, not ends desired but unattained." But the maintenance officer is charged with a greater responsibility than simply showing the facts as to the money expended. He must show efficient accomplishment and satisfactory condition of property. In other words, he must have good riding track, nice appearing structures and still keep within his maintenance allowance.

Since the forces destructive to track are at work throughout the year, it seems logical that the expense for doing renewal work should also be spread out over the entire year, rather than to have the burden of these expenditures fall within a few months of the year. Therefore, it seems

that the policy of the equalization of expenditures is economically sound and should be generally adopted, and we wish to repeat the

Conclusion

The equalization of expenses permits work to be done at the most economical time, seasonal and traffic conditions considered. It also prevents the distortion of operating ratios, while by its application more uniform forces may be employed in maintenance of way work, thereby tending toward stabilization of forces.

THE DETERMINATION OF THE EXTENT TO WHICH THE MAINTENANCE OF UNIFORM FORCES IS JUSTIFIED

Your Committee has made further analysis of labor payroll reports and mass information on labor turnover conditions, and does not find that the average turnover is any less than that reported last year on page 285 and page 286 of the 1927 Proceedings. It, therefore, seems very essential that sufficient year around work be provided in order that a normal force be kept employed throughout the year.

On page 286 of the 1927 Proceedings, there was published a list of "Accounts affected by work that can be economically done in winter months." Among this list, we wish to call to your particular attention Accounts Nos. 214, 216 and 220, which apply to rail renewals in general, as this is the most promising field for steady employment of track gangs in the winter months. However, Account No. 220 covers adzing and gaging rail; tightening bolts and driving down spikes and other items that are too often postponed during the rush of summer work and are not given the attention that they should receive.

We believe that ample work can be found to keep a normal maintenance of way force economically employed during the winter months, and thus prevent the necessity for large force increases during the summer.

Where men are given a reasonable assurance of steady employment, they will strive to put forth their best efforts in order that they may retain their positions and, of course, the longer they serve the more experience they obtain and the more valuable they become to their employer. A new man that is unacquainted with the work that he is to perform is of little value until he has secured a general knowledge of the work that he is engaged in. Therefore, we do not believe that a track man is more than 50 per cent efficient until he has served at least three months, and with present day methods of laying these men off as soon as the summer work is completed, our labor must necessarily be anything but efficient, and we think that this whole subject is well summed up in the following

Conclusion

In consideration of the ultimate economy of building a strong personnel of labor forces and the immediate economy of holding experienced men in maintenance of way service, as much work as is economically possible should be done in the winter, thus stabilizing forces.

THE EFFECT OF STABILIZATION OF EMPLOYMENT ON UNIFORM PURCHASES OF MATERIALS AND ON THEIR COSTS

The cost of maintenance of way work is divided between two major factors, labor and material. The effect of stabilization of forces is reflected largely and most directly in the labor costs. However, since the rate of use of materials varies with the number of men employed, any measure which tends to promote uniformity of employment will at the same time lead to the more uniform use of materials. This, in turn, will tend to the more uniform distribution of their purchase and delivery throughout the year.

Your Committee has discussed this phase very thoroughly with manufacturers of railway supplies, and it is the unanimous opinion that, if material could be furnished the railroads throughout the entire year, rather than for a few working months, the costs to the railroads would be materially decreased, and we believe that this phase of our subject is summed up in the following

Conclusion

Minimum cost is secured through uniform production; reductions in manufacturing costs are directly reflected in prices charged the railroads; stabilization of forces with the resulting increase in the uniformity of use of materials will lead to savings in the cost of materials over and above the savings effected directly through the increased efficiency of the forces.

Your Committee in its four-year study of this subject feels that it has covered the ground very thoroughly, and the more we have studied this matter of stabilizing employment, the more we are able to realize the economies, direct and indirect, that are to be obtained by having a trained force to perform our maintenance of way work, the same as we have for the maintenance of equipment.

We do not find that the average railway officer appreciates the fact that maintenance of way work requires trained men. Therefore, it should be to the interest of all concerned in maintenance of way work to sell this idea, with the end in view of ultimately obtaining a year-around, experienced maintenance of way force.

Appendix B

(2) ECONOMY IN THE USE OF LABOR-SAVING DEVICES

G. M. O'Rourke, Chairman, Sub-Committee; J. F. Dobson, John Evans, H. M. Church, J. B. Mabile, Wm. Carpenter, J. D. Keiley (deceased), H. M. Stout, W. A. Murray, C. S. Joseph.

Your Committee has continued its studies of the economics in the use of labor-saving devices and has submitted a questionnaire to the railways of the United States and Canada for the purpose of ascertaining the economies resulting from the use of (1) Rail-handling devices; (2) Rail-oiling devices; (3) Advantages of using machines such as ditchers singly and in tandem; (4) Use of mechanical, air, and electrically-driven tools.

The returns from this questionnaire indicated a lack of detailed information on the actual performance of the different machines. While many of the larger railways are using several or all of the different types of machines mentioned and claim economies from their use and operation, they were not in a position at this time to give definite facts and comparisons.

This lack of information is, in all probability, due to recent development of many of these machines and the lack of sufficient time to fully determine their relative value as compared with hand operation.

Your Committee feels that a more limited number of machines should be investigated each year and believes that, by this plan, some definite information on the economies resulting may assembled.

To this end your Committee wishes to report progress in their work and proposes, during the ensuing year, to carry on an exhaustive research covering rail-handling devices.

Appendix C

(3) STANDARDIZATION OF PARTS AND ACCESSORIES FOR RAILWAY MAINTENANCE MOTOR CARS

J. A. Heaman, Chairman, Sub-Committee; J. B. Mabile, F. S. Schwinn, H. A. Cassil, F. M. Thomson, C. C. Cook, W. A. Murray, J. R. Caswell, F. B. Doolittle, E. T. Howson, C. S. Joseph, John Evans.

Your Committee respectfully presents herewith report covering the following subject:

> **Standardization of Parts and Accessories for Railway Maintenance Motor Cars, the Sub-Committee Being Instructed to Work with the Committee of Manufacturers of Motor Cars with a View of Standardization of all Motor Car Parts and Report of Results with such Definite Recommendations as their Handling Would Permit.**

Your Committee has been in correspondence with the manufacturers in an endeavor to secure a report from the Manufacturers' Committee, which organized in February of this year and submitted a report of organization dated February 2, 1927.

From the replies secured from a number of the manufacturers and particularly from Mr. Gilleland, Manager Railway Division, Fairbanks, Morse & Company, who evidently speaks for the Manufacturers' Committee, it appears that the manufacturers are willing to work with Sub-Committee No. 4 toward standardization of motor car parts and accessories, but your Sub-Committee has been unable to arrange a joint meeting between it and the Manufacturers' Committee up to date.

Acting upon the suggestion made at the last Committee meeting at St. Louis, a meeting was called of Sub-Committee No. 4, September 22, 1927, in Buffalo, during the session of the Roadmasters' convention. The representatives of the Motor Car Manufacturers and their committee were requested to attend this meeting, it being the thought that most of these gentlemen would be present at Buffalo at the convention.

A meeting of the Manufacturers' Committee, or their representatives, was held on September 21st, and they wrote your Sub-Committee advising that they had made a thorough investigation and compiled a report and that this report, if approved by the manufacturers—as they expect it to be—would be furnished the Sub-Committee.

The activities of your Sub-Committee have been confined to endeavoring to enlist the aid of the manufacturers in the consideration of standardization of parts and accessories of railway motor cars. The Committee has nothing to show for their efforts, except assurance of the manufacturers that they will work with us. Possibly the report mentioned will indicate this willingness and outline those parts of the motor car that the manufacturers will consider for standardization.

The report of the manufacturers was not available at the last general meeting of Committee XXII; hence your Committee feels there is nothing else to do but to report progress.

Appendix D

(5) EQUATING TRACK VALUES FOR LABOR DISTRIBUTION

J. C. Patterson, Chairman, Sub-Committee; J. F. Dobson, H. M. Church, A. E. Botts, Cale Wamsley, J. M. Sills, C. A. Ashbaugh, H. A. Cassil, J. R. Caswell, F. S. Schwinn, W. S. Burnett, F. B. Doolittle, R. L. Schmid.

In the report for 1922 the Committee on Economics of Railway Labor (Vol. 23, page 685) suggested a definite list of comparative values for reducing the various physical features of track to the equivalent of one mile of first main track. This table of values was derived from actual costs extending over a period of years for a main line division, which was the subject of special study. The values were as follows:

One mile of first main track equivalent to:

1.15 miles of second main track
1.33 miles of third or fourth main track
2.00 miles of branch line track
2.00 miles of passing and thoroughfare track
3.33 miles of yard tracks
12 main track switches
20 side track switches
10 railroad crossings
12 city street crossings
25 to 50 county road crossings
One-half mile of track pans
4 miles of ditches

For the purpose of elasticity in the application of these values to meet the changing conditions of various elements of the track, it was suggested that the condition of the main elements per section be stated monthly and a "Condition per cent" of the whole section determined. This result, applied to the equivalent mileage, as determined from the table of values referred to, gave the equated mileage for the section.

The ratio of the equated mileage of the section to the total equated mileage of the division determined the number of men allotted to the section from the total number of men allotted the division.

The above method of "Force Distribution" was submitted as information and so received.

In order to determine the necessity or desirability of equating additional features of track maintenance for use in labor distribution, a questionnaire was issued to 57 member railways requesting information as to the results of the application of the suggested method of force distribution. Replies were received from 26 railways, 14 advised they do not equate track values for the purpose of distribution of track labor, and 12 advised they do equate track values for that purpose.

None uses the "Condition per cent" in determining the equated mileage. Of the 12 railways reporting use of equated mileage, 4 use the items suggested by the Committee, 4 use a less number of items and 4 use a greater number. These 4 railroads equate 32 additional items, not one

of which is common to the 4 railways. Two items are common to 3 railways and only 8 items are common to 2 railways.

Consideration of the replies to the questionnaire and deliberation of the Committee lead to the conclusion that no extension generally is necessary or desirable in the number of features to be equated and that the comparative values heretofore suggested by the Committee are reasonable. It is evident that there are peculiar features of maintenance on individual railroads that affect the force required and railroads having such peculiar features should add them to the list above stated and apply values thereto which they deem proper.

It is well known that the work necessary to be performed on a section will vary from year to year, due to the changing conditions of various elements of the track and the Committee endeavored to compensate for this by suggesting a "Condition per cent."

It appears that judgment enters so largely into any distribution of labor that it is desirable, if possible, to find some method of aiding judgment or an accurate substitute for that judgment.

There are several elements in the problem (1) the physical units, (2) condition of the units, (3) use of the property and (4) characteristics of the railway as to curvature and grades. As to the first item, physical units, the units heretofore suggested are considered sufficient. As to the second item, condition of units, the report of the Committee presented in 1922 gave in Exhibit "J" a method of arriving at the "Condition per cent" which could be applied to the equated mileage for each section so as to give an equitable distribution of labor. It is probable that the method there described can be simplified so that it will be more practicable in application and the Committee plans to give further study to this feature of the assignment. As to the third term, use of the property, the Committee presents a study made on a railroad in the west to determine the effect upon labor costs of maintenance due to volume of traffic and speed. It was first determined that 40 per cent of the maintenance labor was not affected by traffic, the basis for which was the following:

Kind of Work Not Affected by Traffic—	*Relation to Total Maintenance Labor. Per Cent*
Grassing track and cutting sod line	5.01
Mowing and burning right-of-way	2.69
Dressing ballast shoulder	2.52
Cleaning ditches	2.33
Bridges, trestles and culverts	0.43
Repairing right-of-way fences	1.08
Repairing stock guards and wing fences	0.70
Repairing crossings and signs	1.15
Care of station grounds and buildings	1.79
Caring for switch lamps in yards	0.84
Caring for switch lamps outside of yards	1.91
33 per cent of tie insertions	2.69
25 per cent of lining and surfacing	2.50
25 per cent of rail laying	0.54
33 per cent of spotting	5.51
50 per cent of tightening bolts	1.02
50 per cent of patrolling track	1.93
25 per cent of miscellaneous and other labor	4.95
	39.59

In figuring the man-factor we start with the basis of .40, this being the labor unaffected by traffic. Factors are then built up as follows:

Minimum maintenance labor not affected by traffic.....0.40 per cent
Per million gross tons of freight per mile of track.....0.03 per cent
Per 5,000 cars of passenger equipment.....0.01 per cent
Per 8 miles of maximum speed.....0.01 per cent

For example, assuming that a given stretch of track handles 10,000,000 tons gross freight per mile per year, 20,000 cars of passenger equipment, and is limited to 60 miles per hour speed, the traffic factors would be as follows:

Minimum not affected by traffic.....0.40 per cent
Freight traffic, 10,000,000 tons at 0.3 per million.....0.30 per cent
Passenger traffic, 20,000 cars at 0.1 per 5 million.....0.04 per cent
Speed, 60 miles per hour.....0.08 per cent

Classification factor .....0.82 per cent

Making an assumption that one man per year is necessary to maintain one equated mile of track, 100 equated track miles would require 0.82 times 100 equals 82 men.

In order to make a check on this method, it was applied to a portion of a trunk line railroad in the east on which the data was available with the following results:

Division	*Main Track Miles*	*Gross Tons Per Mile of Main Track*	*Pass. Cars Per Mile of Main Track*	*Speed*	*Equated Miles*	*Man Factor*	*No. of Men Required*	*No. of Men Standard Basis in Use*
A	449.32	5,669,520	38,000	60	726.45	0.72	523	550
B	67.63	539,800	33,400	60	109.36	0.56	61	66
C	42.90	451,000	41,850	60	63.67	0.57	36	45
D	206.50	11,748,600	37,600	50	252.16	0.89	224	211
E	110.41	6,176,171	3,985	60	187.04	0.67	125	146
F	274.00	15,945,500	30,685	60	400.13	1.01	404	365
G	64.74	273,200	3,720	40	86.39	0.47	41	41
H	142.61	1,040,000	8,400	50	196.40	0.51	100	98
I	220.00	5,430,000	7,332	60	364.82	0.65	237	247
Total	1,578.11				2,386.42		1,751	1,769
Figures for territory as a whole:								
	1,578.11	7,250,473	25,876	60	2,386.42	0.74	1,766	1,769

The above result checks as close as any average could be expected to check and being applied on railroads in entirely different territories with different traffic conditions would appear to verify the method proposed.

Having determined the proper working force, the seasonal distribution of the force allowed for the year is necessary. Some railroads make a distinction between summer and winter forces and accomplish this by varying the man-basis per mile of equated track. Another method used by a railway is to determine the man allowance for the year total and apportion 5 per cent of this total for each of the months of January, February and December; 7 per cent for the month of March; 9 per cent for each of the months of April and November, and 10 per cent for each of the months of May to October, inclusive. This method, while satisfactory in the territory in which applied, would vary according to the

geographical location of each railroad, due to climatic conditions and changes in periods of working season. The method outlined is quoted as an example of the principle of allotting the maintenance labor on basis of seasonal requirements.

As to the fourth item, characteristics of the railway as to curvature and grades, it is the intention of the Committee to give further study to that feature for the purpose of establishing the value it should have in the equation.

Conclusion

That the report be accepted as a progress report and that the assignment be continued.

REPORT OF COMMITTEE VII—WOODEN BRIDGES AND TRESTLES

Wm. E. Hawley, *Chairman;*
H. Austill,
F. E. Bates,
E. H. Brown,
Charles Chandler,
C. H. Chapin,
C. R. Chevalier,
F. H. Cramer,
W. J. Gooding,
S. F. Grear,
R. P. Hart,
F. M. Hawthorne,
C. S. Heritage,
A. P. Himes,
W. B. Hodge,
C. J. Hogue,
J. B. Maddock, *Vice-Chairman;*
*W. H. Hoyt,
C. T. Jackson,
M. B. Kent,
L. V. Lienhard,
R. E. Miller,
J. A. Newlin,
C. E. Paul,
G. W. Rear,
Arthur Ridgway,
J. R. Sexton,
D. W. Smith,
M. A. Stainer,
G. C. Tuthill,
J. L. Vogel,
Wm. Walkden,

Committee.

*Died November 10, 1927.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual.

The report of the Sub-Committee on Revision of Manual will be found in Appendix A.

(2) Continue work on simplification of grading rules and classification of timber for railway uses, collaborating with Committee XII—Rules and Organization, and other organizations dealing with this subject.

The report of the Sub-Committee on this subject will be found in Appendix B.

(3) Prepare a revision of present specifications for treated and untreated timber piling, collaborating with Committee XVII—Wood Preservation. A specification for piles is offered in Appendix C.

(4) Study and report advantage of establishing supply yards for standard trestle timbers at various locations throughout the country.

The Sub-Committee having this subject offers a progress report in Appendix D and desires to continue the study.

(5) Study and report on the standardization and simplification of store stock and disposition of material reaching obsolescence, collaborating with other committees and organizations concerned.

This is a new subject with the Committee and of such a nature that it can only be handled when plenty of time is available and more time will be required than it has been possible to give to the subject.

The recommended suggestions for future work of the Committee are therefore as follows:

1. Revision of the Manual.

2. Continue work on simplification of grading rules and classification of timber for railway uses, collaborating with other organizations dealing with the subject.

3. Study and report advantage of establishing supply yards for standard trestle timbers at various locations throughout the country.

4. Study and report on the standardization and simplification of store stock and disposition of material reaching obsolescence, collaborating with other committees and organizations concerned.

5. Study economic comparison of reinforced concrete trestles as against wooden trestles.

6. Outline of work for ensuing year.

Action Recommended

1. That the specifications for piles in Appendix C be adopted by the Association for printing in the Manual.

2. That the other reports be received as progress and the subjects continued as noted.

Respectfully submitted,

The Committee on Wooden Bridges and Trestles,

Wm. E. Hawley, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

H. Austill, Chairman, Sub-Committee; Charles Chandler, F. H. Cramer, C. J. Hogue, W. H. Hoyt, M. B. Kent, L. V. Lienhard, J. A. Newlin, C. E. Paul, Arthur Ridgway, G. C. Tuthill.

In anticipation of a revised edition of the Manual, the Committee last year completed the editorial and typographical changes in its material now appearing therein, considered necessary.

The Committee has no further changes to recommend at this time.

Appendix B

(2) SIMPLIFICATION OF GRADING RULES AND CLASSIFICATION OF TIMBER FOR RAILWAY USES, COLLABORATING WITH COMMITTEE XII—RULES AND ORGANIZATION, AND OTHER ORGANIZATIONS DEALING WITH THIS SUBJECT

C. J. Hogue, Chairman, Sub-Committee; H. Austill, Charles Chandler, J. B. Maddock, J. A. Newlin, D. W. Smith.

This subject provides for the keeping of contact with the lumber standardization efforts in this country and its application to the railway requirements. Such contact is being maintained by this Committee.

The lumber standardization in softwood industry from which standards were drawn and adopted by the A.R.E.A. last year has reached the point at which a look backward and another year's trial might be made without further revision. Hence it was not thought necessary that the lumber industry should need hold an annual conference in Washington in May, 1927, and none was held. This is a sign that real progress has been made and a fair degree of unanimity of opinion in the industry has been secured. Hence the Committee has not found it necessary to report new revisions to these standards.

The emphasis has now passed from the formation of the standards to the securing of the more general use of these standards by all users. It is here that the Committee desires to ask that the railways of America shall give their support to these new standards by using them in all their designs, orders for materials, and inspections.

The lumber associations have revised their rule books to conform to these American Lumber Standards, and it would seem desirable to replace previous rules with the American Standard rules. Orders placed on basis of old rules are confusing to production and pricing.

The Committee is fully aware that even some of the lumber agencies are offering material to the railway purchasing departments on the old rules, and that some mills have not chosen to use the new rules, but this Committee is unanimous that it is in the best interests of the railways that all material shall be specified and bought on the new rules. We believe that when the transition period is over that all concerned will be glad for the unification of the industry.

In the hardwood situation, the Committee has had to wait until the industry could come to some conclusions as to the rules under which it will operate. Great progress has been made in developing a set of rules which have secured the support of 65 per cent of the members of the National Hardwood Lumber Association, but which under their rules must receive a two-thirds favorable vote before adoption. The new rules failed to secure this two-thirds and hence were referred back for further work this year.

In the nature of the relations the Committee deems it best to follow rather than to lead in a field in which the railways have not as large an interest as they have in the softwood industry.

The Committee is keeping in contact with the efforts being put forth by the various public agencies such as the U.S. Department of Commerce in its "Better Utilization of Timber," the U.S. Department of Agriculture promotion of reforestation, the United States Chamber of Commerce in its program of business treatment of reforestation and the National Lumber Manufacturers' Association Trade Extension Program. These are all working toward the perpetuation of the supply of timber by assuring profit in reproduction. The railways are interested in the perpetuation of their supply of timber, and should lend moral support to all such agencies as will take off the railways the necessity for growing their own timber and leave it in the hands of those best fitted to produce this material.

APPENDIX C

(3) PREPARE A REVISION OF PRESENT SPECIFICATIONS FOR TREATED AND UNTREATED TIMBER PILING, COLLABORATING WITH COMMITTEE XVII—WOOD PRESERVATION

C. E. Paul, Chairman, Sub-Committee; F. E. Bates, C. H. Chapin, C. R. Chevalier, F. H. Cramer, A. P. Himes, C. J. Hogue, C. T. Jackson, M. B. Kent, R. E. Miller, J. A. Newlin, G. W. Rear, J. R. Sexton, M. A. Stainer, G. C. Tuthill, J. L. Vogel.

This instruction has been followed and specifications for piles are offered herewith. These specifications are for piles untreated, but contain provisions which are suitable for material to be treated by processes which are specified by the Wood Preservation Committee.

The specifications relate to round piling. Where sawed timber piles, such as heavy sheet piles, are desired, the Committee recommends that appropriate specifications be drawn from the timber specifications already adopted by this Association.

The specifications have been opened to fire or blight-killed, or wind-felled timber in the interest of conservation, and because it has been shown by the Forest Products Laboratory that such timber, if not attacked by insects or decay, is just as strong as so-called live timber.

SPECIFICATIONS FOR TIMBER PILES

Kinds of Wood

1. The railway will specify the kind or kinds of wood* it desires to use, and will designate the kinds it desires for preservative treatment.

2. Piles of different kinds of wood must be delivered in separate lots.

*The most commonly used species are cedars, cypress, Douglas fir, oaks, pines and spruces.

Physical Requirements

General Quality

3. Except as hereinafter provided, all piles shall be free from any defects which may impair their strength or durability as piling, such as decay, red heart, splits in piles to be treated, or splits longer than measured butt diameter of piles not to be treated, twist of grain exceeding one-half of the circumference in any twenty feet of length, unsound knots, numerous knots or holes, or shake more than one-third of the diameter of pile. Sound knots will be permitted, provided they are not in clusters. The maximum diameter of a sound knot shall not exceed one-third of the least diameter of the section where it occurs, and shall not exceed four inches. A sound knot shall be one which at a depth not greater than its diameter shows wood as hard as that surrounding the knot.

4. All piles shall be cut from sound, live trees, except that fire or blight-killed, or wind-felled timber may be used if not attacked by decay or insects.

5. The tip must be sound.

6. The butt end must be sound in all except cedar piles, which may have a pipe or stump rot hole not more than 1½ inches in diameter.

7. The diameter of a pile in cases where the tree is not exactly round, should be ascertained by measuring the circumference and dividing the number of inches in it by the number 3.14.*

8. Piles shall taper uniformly from the point of butt measurement to the tip.

Close Grain

9. If close grain is specified for softwood piles, they shall show on the butt end not less than six annual rings per inch, measured radially over the outer three inches of the cross-section. Douglas fir and Southern pine averaging from five to six annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

Resistance to Decay

10. Piles for use without preservative treatment shall have as little sapwood as possible.

11. Piles for use with preservative treatment shall have no sapwood restrictions, but have, preferably, as much sapwood as possible; in Southern pine a thickness of not less than 1½ inches and in Douglas fir of not less than one inch on the butt end. Care shall be taken to remove as little sapwood as possible while peeling bark. The sapwood shall not be injured by unnecessary axe cuts. These piles shall be designated as sap piles.

*This diameter may be determined by using a steel tape suitably marked to give the diameter by measuring the circumference.

Design

Dimensions—First-Class Piles

12. Southern pine and Douglas fir piles shall have the following limiting dimensions:

Length	Diameter 3 ft. from Butt Min.	Max.	Diameter of Tip Min.
Under 40 ft.	14 in.	18 in.	10 in.
40 ft. to 50 ft.	14 in.	18 in.	9 in.
50 ft. to 70 ft.	14 in.	18 in.	8 in.
70 ft. to 90 ft.	14 in.	18 in.	7 in.
Over 90 ft.	14 in.	20 in.	6 in.

13. Red oak, willow oak, black oak, white oak, pin oak, post or burr oak, or cypress piles shall have the following limiting dimensions:

Length	Diameter 6 ft. from Butt Min.	Max.	Diameter of Tip Min.
Under 30 ft.	12 in.	18 in.	10 in.
30 ft. to 40 ft.	12 in.	18 in.	9 in.
Over 40 ft.	12 in.	18 in.	8 in.

14. Western red cedar piles shall have the following limiting dimensions:

Length	Diameter 6 ft. from Butt Min.	Max. Widest Part	Diameter of Tip Min. any Point
30 ft. or less	14 in.	22 in.	10 in.
30 ft. to 40 ft.	14 in.	22 in.	9 in.
Over 40 ft.	14 in.	22 in.	8 in.

Dimensions—Second-Class Piles

15. Piles for foundations that will always be completely submerged, and piles for coffer-dams, falsework and sundry temporary work may be of sound, live timber that will stand driving, and need not be peeled. They shall be free from bad knots, decayed timber, shakes and other imperfections which will seriously affect their strength. They shall be of the following general dimensions:

Length	Diameter 3 ft. from Butt Min.	Max.	Diameter of Tip Min.
40 ft. or less	12 in.	18 in.	8 in.
Over 40 ft.	12 in.	18 in.	6 in.

Tolerance

16. Dimensions given are minimum or maximum as stated, but a tolerance of ½ inch less in a given diameter will be allowed in not more than 25 per cent of the pieces of that diameter.

Length

17. All piles shall be furnished on order cut to any of the following lengths: 16 feet to 40 feet in multiples of two feet and over 40 feet in multiples of 5 feet. A variation of six inches in length is allowable, but the average length in any shipment must be equal to, or greater than, the billed length.

Straightness

18. Piles shall be free from short or reversed bends, and free from crooks greater than one-half the diameter of the pile at the middle of the bend. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile.

Manufacture

19. All knots and limbs shall be trimmed or smoothly cut flush with the surface of the pile. Ends must be cut square with axis of pile.

20. When specified, piles must be peeled of bark including the inner skin soon after cutting so that the piles are smooth and clean.

Inspection

Place

21. Piles will be inspected at suitable and convenient places satisfactory to the railway, at points of shipment or at destination. Piles will be inspected at points other than the railway's property whenever in the judgment of the railway there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector at the expense of the railway, while away from rail or steamer lines, and shall transport him from and to a railway station or steamer landing.

Manner

22. Inspectors will make a thorough examination of each pile. Each pile shall be judged independently without regard for the decisions on others in the same lot. Piles too muddied for ready examination will be rejected. Piles will be turned over as inspected, at the expense of the producer.

Manufacture

23. Piles shall be inspected for workmanship and conformity with these specifications in all respects.

Delivery

24. Piles delivered on the premises of a railway for inspection shall be stacked not less than 10 feet from the nearest rail of any track, or from highways, at suitable and convenient places, but not at public crossings, nor where they will interfere with the view of trainmen or of people approaching the railway. Piles shall be stacked in a secure manner in order that they shall not roll onto the railroad tracks or highway.

25. Each stack shall have fastened to it a tag on which is written the owner's name and address, the date when stacked, and the number of piles of each kind of wood in the stack. Piles for use without preservative treatment and those for preservative treatment shall be stacked separately.

26. All piles are at the owner's risk until accepted. All rejected piles shall be removed within one month after inspection, if required by the railway.

Shipment

27. Piles forwarded in cars or vessels shall be separated therein according to the kinds, sizes and lengths if inspected before loading, or as may be stipulated in the contract or order for them.

Appendix D

(4) STUDY AND REPORT ADVANTAGES OF ESTABLISHING SUPPLY YARDS FOR STANDARD TRESTLE TIMBERS AT VARIOUS LOCATIONS THROUGHOUT THE COUNTRY

S. F. Grear, Chairman, Sub-Committee; F. E. Bates, E. H. Brown, C. H. Chapin, F. H. Cramer, W. J. Gooding, R. P. Hart, F. M. Hawthorne, A. P. Himes, W. B. Hodge, C. J. Hogue, L. V. Lienhard, R. E. Miller, G. W. Rear, J. R. Sexton.

A questionnaire was sent to members of the Association in order to get the reaction to such a proposal for supply yards. Eightly-two replies have been received, of which thirty-seven are from Chief Engineers, four from Store Department officials, and the balance from other railway officials, such as Engineers Maintenance of Way, Engineers of Bridges, Superintendents of Bridges, etc.

Question No. 7 reads as follows: Should the Association recommend to producers the establishing of commercial yards?

Answers to this question are tabulated as follows:

Of the Chief Engineers twenty-three are opposed to the Association making such recommendations, three are in favor of the recommendation, and the other eleven are either non-committal or have given qualified answers.

Of the four Store Department officials, none favor this recommendation.

Of the remaining forty-one answers, twenty-two are opposed to the recommendation, nine are in favor of it, and ten are non-committal or gave qualified answers.

Question No. 8 reads as follows: Should the Association recommend the establishing of joint railway supply yards?

Answers to this question are tabulated as follows:

Of the Chief Engineers twenty-four are opposed to the recommendation, three are in favor of it, and the other ten are non-committal or gave qualified answers.

Of the four Store Department officials, none favored such supply yards.

Of the remaining forty-one answers, twenty-three are opposed to the recommendation, five are in favor of it, and thirteen are non-committal or gave qualified answers.

Question No. 4, concerning commercial yards, reads as follows: Where should such yards be located to serve you?

Included in the thirty-seven replies from Chief Engineers, in twenty-six separate locations are recommended and no two recommended the same city. In the other replies mention is made of thirty-five different locations, Jacksonville, Florida, being the only one mentioned twice.

Question No. 6 is the same as question No. 4 except that it relates to joint railway yards.

Chief Engineers mentioned seven locations, no city being mentioned twice. In the other replies mention is made of twenty-seven different cities, Duluth, Minnesota, being the only one mentioned twice.

With the above data it would appear that it would not be possible, at the present time for the Committee to make a favorable recommendation as to the establishing of commercial yards or yards operated jointly by a group of railways. The Committee recommends that this report be received as information and that the Committee give the subject further study during the coming year.

REPORT OF COMMITTEE XII—RULES AND ORGANIZATION

W. C. Barrett, *Chairman;*
M. M. Backus,
D. P. Beach,
R. G. Bowie,
H. L. Browne,
J. F. Burns,
E. N. Burrows,
P. D. Coons,
J. L. Downs,
H. H. Edgerton,
J. M. Fair,
A. B. Griggs,
E. F. Gorman,
H. H. Harsh,
A. A. Jackson,
E. H. Barnhart, *Vice-Chairman;*
J. L. Jamieson,
B. R. Kulp,
H. G. Laird,
W. C. Mack,
R. D. Martin,
J. A. Peabody,
H. J. Pfeifer,
R. N. Priest,
J. W. Stevens,
C. H. Tillett,
R. E. Warden,
W. H. Wheaton,
F. B. Wiegand,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of the Manual (Appendix A).

2. Continue the study and report on rules for the guidance of employees of the Maintenance of Way Department, including therein:

(a) Duties of motor car operators and maintainers.

(b) Rules for dressing ballast.

(c) Rules for maintenance of bridges and other terminal structures, collaborating with the proper standing committees (Appendices B and C).

3. Study the titles below rank of Division Engineer, which are employed to designate positions of corresponding rank in maintenance of way service, and make recommendations that will promote uniformity in nomenclature.

Action Recommended

1. That the changes in the Manual in Appendix A be approved and the revised version substituted for the present recommendation in the Manual.

2. (a) The Committee reports progress on this assignment but has no definite recommendation to make this year.

(b) Rules for dressing ballast are incorporated in revised rules for ballasting found in Appendix A.

(c) Rules were assembled in collaboration with Committee VII—Wooden Bridges and Trestles and Committee XVII—Wood Preservation, covering that part of this assignment which calls for rules for maintenance of bridges. The rules prepared are found in Appendix B and are submitted as information only.

Some work was done in collaboration with other standing committees on that part of the assignment which covers rules for maintenance of other terminal structures. The result is shown in Appendix C and is submitted as information only.

3. A questionnaire was sent to various railroads by the Secretary of the Association to develop information on this subject. Some replies have been received but the Committee is not prepared to make definite recommendation this year.

Recommendation for Future Work

1. Revision of the Manual, making a study of the subject-matter of each standing committee, distinguishing where necessary between rules and specifications, collaborating with standing committees concerned therewith.

2. Continue the study and report on rules for the guidance of employees of the Maintenance of Way Department, with special reference to:

(a) Duties of motor car operators and maintainers.
(b) Rules for maintenance of buildings.
(c) Rules for maintenance of bridges.
(d) Rules for maintenance of other terminal structures.

3. Continue the study of titles below rank of Division Engineer, which are employed to designate positions of corresponding rank in maintenance of way service, and make recommendations that will promote uniformity in nomenclature.

4. Prepare rules for fire prevention as applying to railway property.

5. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Rules and Organization,
W. C. Barrett, *Chairman.*

DEFINITION OF THE TERMS "RULE" AND "SPECIFICATION"

Adopted by the Board of Direction March 10, 1927

"Rule—A law or order authoritatively governing conduct or action."

"Specification—A definition of quality or design of material or workmanship or of process that is required; a statement prescribing details of a plan."

Appendix A

(1) REVISION AND DEVELOPMENT OF PRESENT RULES FOR GUIDANCE OF EMPLOYEES OF MAINTENANCE OF WAY AND STRUCTURES DEPARTMENT

M. M. Backus, Chairman, Sub-Committee.

(Prepared by Committee XII in collaboration with proper standing committees)

TRACK

Ties

Present Form	*Proposed Form*
Storage of	**Storage of**
695. Ties stored along the right of way must be stacked to conform to the standard plans, according to class, shape and location. Stacks must be placed on ground bare of debris or vegetation for at least two feet around each stack and clear of vegetation over six inches high within ten feet of any stack and sufficiently well drained so that water will not stand under the stacks or in the immediate vicinity. Decaying wood debris must be entirely removed.	695. Ties stored along the right of way must be stacked to conform to the standard plans, according to class, shape and location. Stacks must be placed on ground bare of debris or vegetation for at least two feet around each stack and clear of vegetation over six inches high within ten feet of any stack and sufficiently well drained so that water will not stand under the stacks or in the immediate vicinity. Decayed ties or wood must not be used for sills. Decaying wood debris must be entirely removed.
None.	**Renewals—Method of** 709. Any kind of tie which starts to split in track should have an anti-splitting device applied promptly.
None.	**Dating Nails** 711. When dating nails are applied after the tie is in the track they must be driven the same day the tie is inserted.
None.	712. The section foreman must see that marks or nails intended to identify ties are not injured or destroyed.

TRACK SPIKES

Present Form	*Proposed Form*
765. Spikes must be driven until the heads are in contact with base of rail, but not driven too far, thereby bending the neck and causing the head to crack or break off.	764. Spikes must be started and driven vertically and square, and so driven that the face of the spike shall come in contact with the base of the rail; but not driven so far as to cause the neck to bend and/or the head to crack or break off.
None.	765. Where track is to be spiked to standard gage, the rail must be held against the gage with a bar while the spike is being driven.

BALLAST

Present Form	*Proposed Form*
Cross-Section	**General**
780. The cross-section of the ballast must conform to the standard plans.	780. The kind and amount of ballast to be applied should be determined by the proper official.
None.	781. The Division Engineer should lay his plans for work train service before the Division Superintendent in order that there may be a clear understanding of what is desired to be done.
None.	782. Speed restrictions must be arranged for in accordance with operating rules before track is disturbed and must be maintained until track is in safe condition for schedule speed.
793. Section foremen must provide proper protection by slow order, caution signs, or flag, or all of these, if necessary, when raising track, and must, except in emergency, raise against the current of traffic, where there is more than one track. A long easy runoff must always be prepared ahead of fast passenger trains.	783. Section foremen must provide proper protection by slow order, caution signs, or flag, or all of these, if necessary, when raising track, and must, except in emergency, raise against the current of traffic, where there is more than one track. A long easy runoff must always be prepared ahead of fast passenger trains.
None.	784. A careful inspection of pit tracks and appurtenances must be made and everything put in serviceable condition if the ballast is to be secured from a Railway Company pit or from one for which the Company is responsible.
	Preparatory
None.	785. Preparatory to placing ballast, the roadbed must be widened, if necessary, to bring it to the A.R.E.A. standard width, by dumping material alongside of the track and spreading it to the required width and slope, by the use of a material spreader, if available. Where necessary to raise the roadbed level, porous material must be used to avoid the forming of water pockets.
None.	786. All bank widening must be done far enough in advance of the ballasting work so that there will be no interference with progress of the work.
791. Where directed by the Division Engineer, preparatory to the distribution of new ballast, all old ballast and unsuitable material must be removed to the bottom of the	787. Where directed by the Division Engineer, preparatory to the distribution of new ballast, all old ballast and unsuitable material must be removed to the bottom of the ties,

Present Form	*Proposed Form*
ties, for the full width of the roadbed, the old ballast cleaned, and the unsuitable material used for widening embankments or for other purposes. At the same time, all ties requiring renewal must be replaced and the ties properly spaced, if necessary.	for the full width of the roadbed, the old ballast cleaned, and the unsuitable material used for widening embankments or for other purposes. At the same time, all ties requiring renewal must be replaced and the ties properly spaced, if necessary. The track must be accurately gaged as the new ties are being spiked up. Old ties must be disposed of as directed.
None.	788. Ballast grade stakes must be set after the ditching, bank widening, skeletoning and re-tieing have been done and before the ballast material has been dumped and spread. It is desirable to avoid, as far as possible, interference with the stakes, yet to have them available as a guide for the unloading of ballast.
None.	789. All drains required to take care of water from between tracks must be placed before the ballast is unloaded.
None.	790. Stone and hard slag ballast must be cleaned when so foul as to prevent proper drainage. Cleaning should be to the sub-shoulder and where cribs are cleaned, to the bottom of ties, but if the cribs are not cleaned, cross ditches should be cleaned at least every rail length but no cross ditch should be placed at any rail joint. Cleaning between tracks should be to a depth of six inches or more below the bottom of the ties.
	Unloading
792. When old ballast has been thoroughly cleaned, sufficient new ballast should be unloaded to make the first raise, which is usually made by shovel tamping the ties. When ballasting or surfacing track out of face, both rails must be raised together.	791. When old ballast has been thoroughly cleaned, sufficient new ballast should be unloaded to make the first raise, which is usually made by shovel tamping the ties. When ballasting or surfacing track out of face, both rails must be raised together.
785. Part of,—If special ballast cars are not available, hopper bottom cars must be used.	792. Cars for transporting ballast must be carefully chosen with regard to the work to be done. If for raising track, center dump cars should be used and ballast spread with plow or tie drag. When unloading ballast for a parallel track, side dumps are preferred, especially when air operated. Convertible cars where the sides swing out and up,

Present Form	*Proposed Form*
	when used with side plow and unloading engine drum and cable, are satisfactory when dump cars are not available.
None.	793. Ballast shall be unloaded by dumping or plowing as the cars provided permit. If the ballast be in center dump cars, it must be unloaded by having one or more cars opened a little at a time and allowing the desired amount of ballast to flow out as the train is slowly moved along. If the ballast be on flat or open side cars, it shall be plowed off by means of an unloading machine while the train is standing or moving at such a rate of speed as to provide the desired amount of ballast.
None.	794. The unloaded ballast must be leveled down by means of a plow or a spreader, consisting of a heavy timber placed in front of the leading pair of wheels of the rear truck and so constructed and used as to avoid sliding of the car wheels on the rail.
785. Part of,—When unloading ballast, care must be exercised to secure proper disposition and avoid waste.	795. When unloading ballast, care must be exercised to secure proper distribution and avoid waste.
	Ballasting
None.	796. In using jacks, they must be placed outside the rail and close enough together to prevent undue bending of the rail or overstrain of the joints. When the roadbed material is heavy or holds to the ties tenaciously, it is sometimes necessary to place three or more jacks per rail length. Jacks should be worked in pairs directly opposite each other, and a sufficient number should be used simultaneously, so that no jack will raise the rail more than four inches above its level at the next succeeding jack or place of support.
794. In gravel or broken stone ballast the ties must be tamped from fifteen inches inside the rail out to the ends. If possible, the end of the tie outside of the rail must be tamped first and a train allowed to pass over before tamping on the inside of rail. The space under the rail must be tamped well. The center of the tie must not be tamped.	797. In gravel, stone, chats, chert, slag, hard burnt clay and cinders, the ties must be tamped from fifteen inches inside the rail out to the ends. The end of the tie outside of the rail must be tamped first, and if possible, a train allowed to pass over before tamping on the inside of the rail. The space under the rail must be tamped well. The center of the tie must not be tamped.

Present Form	*Proposed Form*
None.	798. In earth or clay ballast the ties must be tamped from eighteen inches inside the rails out to the ends. The end of the tie outside of the rail must be tamped first, and if possible, a train allowed to pass over before tamping the inside of the rail. The space under the rail must be tamped well. The center of the tie must be tamped loosely with the blade of the shovel. The dirt or clay between the ties must be placed in layers and firmly packed with the feet or otherwise so that water will quickly shed. The earth must not be banked above the bottom of the ends of the ties, the filling between the ties must not touch the rail, and in the middle of the track should be as high, or higher, than the top of the rail.
795. Where track is electrically bonded, the ballast must be kept at least one inch below base of rail. At road crossings, platforms, etc., where this is not practicable, rails may be insulated by painting them with an asphaltum or tar product, and good, clean stone mixed with the same material may be used for at least one foot each side of rails.	799. Where track is electrically bonded, the ballast must be kept at least one inch below base of rail. At road crossings, platforms, etc., where this is not practicable, rails may be insulated by painting them with an asphaltum or tar product, and good, clean stone mixed with the same material may be used for at least one foot each side of rails.
None.	800. Where raise is sufficient to require a filling lift, a preliminary surfacing gang must follow the unloading as closely as the regularity of the ballast supply will permit.
None.	801. The amount which the track should be raised at one lift will depend upon the depth of ballast to be applied. Usually, track should not be raised more than six inches at a lift. Both rails must be raised at one time and as nearly uniformly as practicable.
None.	802. The "filling lift" must be made by jacking the track up to the required height and the ballast then forked or shoveled in and worked to as uniform a surface as possible by the use of shovels. It shall then be left to be compacted by traffic, but a small "lookout" gang must go over it after a few trains have passed, and pick up any spots that show too great an inequality of settlement.

Present Form	*Proposed Form*
None.	803. After a few days, depending upon the amount of traffic over the track, another lift shall be made, either another filling lift or a finishing lift, according to the depth to which the track is to be ballasted. If another filling lift, it must be made in the same manner as the first one.
None.	804. When the track has been raised to within two or three inches of the final grade and properly compacted, a finishing lift must be made by jacking up the track to the desired grade, and the necessary ballast forked or shoveled in and then driven to place by the tamping machines, tamping picks or bars, if rock or heavy ballast is used. Shovel tamping should be used with gumbo, cinder or light sandy gravel ballast. In making all lifts, the spot board and level board must be used with care, and the track brought to surface.
None.	805. Center stakes must be set for the alignment before the finishing lift is made, and the final alignment must conform to the center stakes.
790. Track must be kept in good line and surface while ballasting. The ballast program should be so arranged, and the supply so regulated as to leave the least possible open track when the season closes. During the progress of ballasting, open track must be watched carefully and protected with the prescribed slow signals, if necessary.	806. The track must be placed in good alignment before the finishing lift is made, but a lining and surfacing gang shall follow one or two days' work behind the finishing lift to pick up all low spots and give the track the final alignment.
None.	807. After the track has been given final line and surface, the track center shall be filled in to the required depth and ballast dressed out to the proper shoulder or toe, using a template if necessary to secure the standard section.
None.	808. Boulders, clinkers or any refuse from the ballast must be removed and disposed of so as to not disfigure the right of way and interfere with the mowing.
796. The following tools shall be used; For broken stone or furnace slag ballast: Shovel, tamping pick and stone fork. For gravel, chats, chert or cinder ballast: Shovel, tamping pick or tamping bar.	809. The following tools should be used: For stone or slag ballast—shovel, tamping pick, tamping machine and stone fork; for gravel, chats, chert, hard burnt clay, or cinder ballast—shovel, tamping pick or tamping bar; for earth or clay ballast—shovel or tamping bar.

Present Form	*Proposed Form*
None.	810. When not surfacing out of face, as in the case of picking up low joints or other low places, the general level of the track must not be disturbed.

LINING AND SURFACING

Gaging	**Gaging**
832. Where frogs occur on the inside of curves, the gage at the frog must be standard, unless a frog with widened flangeway is used.	832. Where frogs occur on the inside of curves, the gage at the frog must be standard, unless a frog with widened flangeway is used, in which case gage must be widened to correspond with widened flangeway.

ROAD CROSSINGS

None.	883. Holes or pockets in bituminous crossings must be repaired as soon as they appear and a small quantity of material should be kept on hand for this purpose.

WATER SERVICE

	Reading and Testing Meters
None.	1759. Employee must make sure water meter is registering before attempting to read it.
None.	1760. Employee must note the values of the unit on each dial and that one complete revolution of the pointer is equal to one division on the dial of next higher value.
None.	1761. To test meter, employee must weigh the water delivered through one complete revolution of the pointer on the first dial of the meter, allowing sixty-two and five-tenths pounds to the cubic foot of water registered. If this method is impracticable meters may be tested in place by using a hose or pipe from the outlet of meter to a test meter of known accuracy.

Appendix B

(2c) RULES FOR HANDLING, FRAMING AND STORING TREATED PILING AND TIMBERS

R. N. Priest, Chairman, Sub-Committee

(Submitted as information only)

1. In handling, any tool that will puncture or otherwise injure the treatment must not be used.

2. Care must be used in unloading piling or timbers to avoid cracking or otherwise injuring them.

3. Piling must not be bored for staging.

4. Piling must not be adzed to frame sway braces.

5. Sway braces must be fitted from the bottom and any cutting found necessary must be made at the top.

6. Wherever it is necessary to cut treated piling or timbers or they become scarred or abraded, the abrasion must be carefully trimmed and there must be applied to the cut or abraded surface, three coats of hot creosote oil and surface must be covered with roofing pitch.

7. Before caps are placed and following the brush treatment, the pile heads must be covered with a tar or asphaltic fabric.

8. Hot creosote oil must be forced in all holes before driving bolts. Unused holes must be likewise treated and plugged with creosoted plugs.

9. Piling or timbers must not be cut or bored below high water mark.

10. Piling must be driven as soon as possible after treatment. When necessary to store them, they must be stacked closely on the ground free of all vegetation and the top of the stack covered with earth to prevent checking.

11. All unused or untreated piling or timbers must be removed from the water in the vicinity.

Appendix C

(2c) RULES FOR MAINTENANCE OF OTHER TERMINAL STRUCTURES

A. B. Griggs, Chairman, Sub-Committee

(Submitted as information only)

Machine and Other Shop Buildings

(1) Where fans are used, special attention should be given to their maintenance, and duplicate of wearing parts should be kept on hand at all times.

Oil Houses

(1) Oil houses at terminals should be separated from other buildings.

(2) Oils that are stored in large quantities should be delivered to the tanks in the house direct from tank cars. For oils that are stored only in small quantities, provision should be made for delivery to storage tanks from barrels by pipes through the floor.

(3) The delivery system from the storage tanks to the faucets should be such that the oil can be delivered quickly and measured automatically. The delivery should also be such that there will be a minimum of dripping at the faucet and that the dripping may drain back to the storage tanks.

Coaling Stations

(1) Special attention should be given to maintenance of bins, pens, chutes and working apparatus of gravity type coaling stations.

Ash Pits

(1) Where brick or concrete materials form any part of the support of the track over the pit, particular attention should be given to the maintenance of these parts.

(2) Approaches to pits and fastenings to steel beams should be given constant attention.

(3) Water connection should be provided and strict supervision maintained to see that when fire is dumped from locomotives that water is immediately applied in order to prevent destruction of the pit walls and track supports.

Turntables

(1) All refuse and dirt must be kept off the deck and out of the pit at all times.

(2) The center bearing of turntables must be kept clean and properly lubricated.

(3) At stated intervals, the turntables should be jacked up and center carefully examined, cleaned and lubricated.

(4) Top flanges and cross bracing of turntables must be kept clean.

(5) Turntables should be cleaned and painted as provided for iron and metal structures, so as to prevent corrosion.

Track Scales

(1) All track scales should be numbered and referred to by number and location.

(2) Extensive repairs to scales, such as renewal of or sharpening of pivots, should be made in a properly appointed shop.

(3) Track scales must be kept well drained, free from dirt, snow and ice, and pit must be cleaned out when necessary. In removing snow and ice, salt must not be used.

(4) The best rust preventatives obtainable should be applied to pivot and heavy steel bearings, but it should be so applied as not to interfere with the proper working of the scale.

(5) Where compressed air facilities are available provision should be made for loose hose connection so that dust and dirt can be blown off of the scale.

(6) Where compressed air facilities are not available provision should be made for connections with weigh engines for blowing dust and dirt from scales as may be required.

REPORT OF COMMITTEE I—ROADWAY

C. W. Baldridge, *Chairman;*
Anton Anderson,
H. B. Barry,
E. J. Bayer,
A. E. Botts,
W. G. Brown,
Paul Chipman,
H. A. Dixon,
M. H. Doughty,
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J. C. Holden,
W. H. Woodbury, *Vice-Chairman;*
A. A. Johnson,
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E. C. Oyler,
O. V. Parsons,
E. M. Smith,
W. C. Swartout,
H. E. Tyrrell,
Jamison Vawter,
W. D. Wiggins,
J. R. Wilks,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith a report covering the subjects assigned to it for the year's work, and we recommend action upon the reports as follows:

Subject No. 1—Revision of the Manual

The report of the Committee is given in Appendix A, and since no revisions of the Manual are offered, no action is recommended.

Subject No. 2—Study of Corrugated Metal Culverts

The report of the Committee is given in Appendix B. The Committee offers the report as information and requests that the subject be reassigned.

Subject No. 3—Study of Deformations of Roadbed

The report of the Committee is given in Appendix C. The report is offered as information and it is recommended that the subject be reassigned.

Subject No. 4—Study of Improved Methods for Preventing Corrosion of Fence Wire

The Committee reports progress and asks that the subject be reassigned.

Subject No. 5—Study of Specifications for Steel Fence Posts

The report of the Committee is given in Appendix E. The Committee recommends that the specifications for metal fence posts be adopted for inclusion in the Manual, and that the subject be discontinued.

Subject No. 6—Permanent Roadbed Construction

The report of the Committee is given in Appendix F. The report is offered as information, and it is recommended that the subject be reassigned.

Subject No. 7—Methods for Policing the Right-of-Way

The report of the Committee is given in Appendix G. The report is offered as information and it is recommended that the subject be discontinued.

Subject No. 8—Outline of Work for the Ensuing Year

The following subjects are offered to the Committee on Outline of Work for their consideration in making their assignments to this Committee for next year's work. The Committee recommends that subjects Nos. 2, 3, 4 and 6 of the past year's outline, be reassigned; also, that other subjects be assigned as follows:

(A) Where and under what conditions should culverts be used in railway construction and maintenance and factors which determine the most suitable kind to be used.

(B) Drainage areas, and water runoff and sizes of waterway openings required under the differing conditions in various parts of the country.

(C) Specifications for concrete arch, concrete box and concrete pipe culverts.

(D) Specifications for cast iron and corrugated and other sheet metal culverts.

(E) Means of avoiding the burying in of ballast, and prevention of water pockets therefrom, when widening and building up embankments.

The Committee desires to acknowledge the aid of Committee V—Track, in the preparation of the report on the subject of Permanent Roadbed and we thank that Committee and its members participating for the assistance given to us.

Respectfully submitted,

The Committee on Roadway,

C. W. Baldridge, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

E. C. Oyler, Chairman, Sub-Committee; H. B. Barry, H. A. Dixon, W. A. Murray, O. V. Parsons, E. M. Smith, H. E. Tyrrell.

We have no revisions to recommend, due to the fact that the Committee has thoroughly reviewed and revised the subject-matter of the Manual within the last few years.

Appendix B

(2) CORRUGATED METAL CULVERTS FOR RAILWAY PURPOSES

W. H. Woodbury, Chairman, Sub-Committee; J. C. Holden, Noah Johnson, W. C. Swartout, Jamison Vawter, J. R. Wilks.

The Committee has made but little progress in the analysis of loads on corrugated culverts. The number of variable quantities that enter into the problem is so large that results from tests other than the ones made at Farina will have to be included in the analysis in order that the Committee will not be misled into erroneous conclusions. Information from tests that are now being made at various points will be necessary before very much more progress can be made.

Loads on and Stresses in Corrugated Metal Culverts

The problem is of such a character, on account of the many variable factors, that a final determination of either the loads acting on the culvert, or of the stresses resulting therefrom can not be made from a strictly theoretical mathematical treatment of the subject. Such mathematical treatment will have to contain certain empirical coefficients.

The Committee submits the following mathematical theory which covers what is available at the present time, and shows how it compares with the tests at Farina, Illinois. Due to the present lack of empirical coefficients it has been necessary to use theoretical quantities, as well as they could be determined.

The following nomenclature will be used:

D = the greatest horizontal outside width of culvert.
pD = the projection of the top of the culvert above the level surface of adjacent solid ground.
H = the total height of the top of the embankment above the top of the culvert.
He = the "height of equal settlement," which is that height of embankment above the top of the culvert at which equal settlement occurs over the culvert and at each side due to the addition of any added uniform horizontal layer of embankment.
Wc = the total vertical load per unit of length on the culvert from embankment materials.
V = the total vertical pressure in the prism of embankment directly over the culvert, per unit length, at any level.
w = the weight of the embankment materials per unit volume.
u = the coefficient of internal friction of the embankment materials ($= \tan \Phi$).
k = the ratio of lateral to vertical pressure in the embankment materials (considered constant and given Rankine's value $\frac{1 - \sin \Phi}{1 + \sin \Phi}$).
e = the base of natural logarithms.
Cr = coefficient of loads for rigid culverts.
Cf = coefficient of loads for flexible culverts.

Culverts, in their action under embankment loads, can be divided into two types, rigid and flexible.

In Type I (rigid) the deflection of the culvert plus the settlement of the culvert into the foundation is less than the settlement of the adjacent prism of embankment materials to the top of the culvert plus the settlement of the adjacent prism into the foundation.

In Type II (flexible) the converse is true.

In Type I the adjacent prism of earth exerts a downward frictional force on the prism of earth over the culvert, thus increasing the total load. In Type II this frictional force is upward, thus decreasing the total load carried by the culvert.

Mathematical Theory of Loads on Culverts

Type I

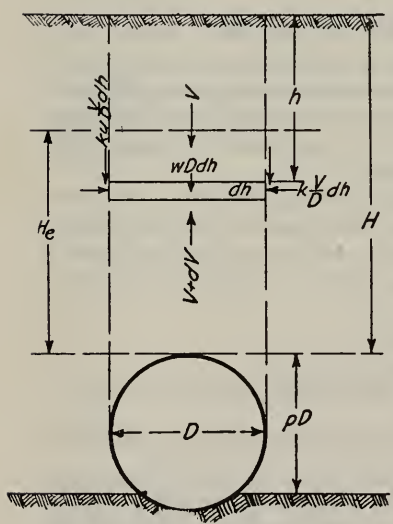


Fig. 1

In Fig. 1 a thin segment of thickness dh is shown with the forces acting upon it.

Case I, H Less Than H_e

$$dV = wD\,dh + 2ku\frac{V}{D}dh \quad \text{.....(a)}$$

$$\frac{dV}{wD + \frac{2ku}{D}V} = dh \quad \text{.....(b)}$$

Solving the differential equation

$$\log\left(wD + \frac{2ku}{D}V\right) = \frac{2ku}{D}h + \text{constant} \quad \text{.....(c)}$$

When $h = O$, $V = O$, therefore constant $= \log wD$

Then

$$\log\left(wD + \frac{2ku}{D}V\right) = \frac{2ku}{D}h + \log wD \quad \text{.....(d)}$$

$$\log\left[\frac{wD + \frac{2ku}{D}V}{wD}\right] = \frac{2ku}{D}h \quad \text{.....(e)}$$

$$\frac{wd + \frac{2ku}{D}V}{wD} = e^{2ku\frac{h}{D}} \quad \text{.....(f)}$$

At top of culvert $h = H$ and $V = W$.

Transposing

$$W_e = \frac{e^{2ku\frac{H}{D}} - 1}{2ku} wD^2 \quad \text{(g)}$$

Or, $W_e = C_r\, wD^2$ ..... (1)

Where $C_r = \dfrac{e^{2ku\frac{H}{D}} - 1}{2ku}$ ..... (2)

Formulas (1) and (2) are good for all values of H up to H_e.

CASE II, H GREATER THAN H_e

Let the notation be the same as in Fig. 1 except,

h = the vertical distance below height H_e.

V_h = the total vertical stress, in prism over culvert, at level h due to embankment materials above height H_e.

$$dV_h = 2ku\frac{V_h}{D}dh \quad \text{(h)}$$

$$\frac{dV_h}{V_h} = \frac{2ku}{D}dh \quad \text{(i)}$$

Solving,

$$\log V_h = \frac{2ku}{D}h + \text{constant} \quad \text{(j)}$$

When $h = O$, $V_h = (H - H_e)wD$, therefore constant $= \log (H - H_e)wD$

Then, $\log \dfrac{V_h}{(H - H_e)wD} = \dfrac{2ku}{D}h$ ..... (k)

$$\frac{V_h}{(H - H_e)wD} = e^{2ku\frac{H}{D}} \quad \text{(l)}$$

$$V_h = (H - H_e)\, wD\, e^{2ku\frac{h}{D}} \quad \text{(m)}$$

At the top of the culvert $h = H_e$ and V_h = the addition to W_e due to the embankment materials above the level H_e.

Therefore, $W_e = \dfrac{e^{2ku\frac{H_e}{D}} - 1}{2ku} wD^2 + \dfrac{H - H_e}{D} e^{2ku\frac{H_e}{D}} wD^2$ ..... (n)

Or, $W_e = C_r wD^2$ .....(1)

$$\text{Where } C_r = \frac{e^{2ku\frac{H_e}{D}} - 1}{2ku} + \frac{H - H_e}{D} e^{2ku\frac{H_e}{D}} \quad \text{.....(3)}$$

To Derive a Formula for Computing H_e

Let E = modulus of elasticity of embankment materials.

Then the total settlements due to the embankment materials above the level H_e are:

$$\text{At each side of culvert} = \frac{(H - H_e)w}{E}(H_e + pD)$$

$$\text{Over culvert} = \int_0^{H_e} \frac{\frac{V_h}{D}}{E} dh$$

Substituting from (m)

$$= \frac{(H - H_e)w}{E} \int_0^{H_e} e^{2ku\frac{h}{D}} dh$$

Equating the two settlements,

$$H_e + pD = \int_0^{H_e} e^{2ku\frac{h}{D}} dh = {}_0^{H_e}\left[\frac{e^{2ku\frac{h}{D}}}{\frac{2ku}{D}}\right] = \frac{D}{2ku}\left(e^{2ku\frac{H_e}{D}} - 1\right). \text{(o)}$$

$$\text{Or } e^{2ku\frac{H_e}{D}} - 2ku\frac{H_e}{D} = 2kup + 1 \quad \text{.....(4)}$$

The above theory, with a few slight changes in nomenclature, has been taken from various bulletins and papers by Dean Anson Marston. The formulas agree very closely with his experimental work in which he allowed no settlement and no deflection of the culverts. If these become more than a slight amount they will have an appreciable effect on the results.

In his later publications, Dean Marston has shown how the formulas given above should be modified in a simple way to allow for the effects of settlement and deflection. (See Proceedings, Highway Research Board, December, 1925.)

Type II

The Committee was, at first, not quite certain whether a similar treatment would apply to flexible culverts. It was finally decided that the same conditions would hold good except that the friction would act upward on the prism of earth over the culvert. Photo 1 shows the action in a sand box where the effect of the culvert deflection was exaggerated by lowering a segment of the bottom. This indicates that the maximum friction is along a vertical plane on either side of the culvert and also that there is a height of equal settlement.

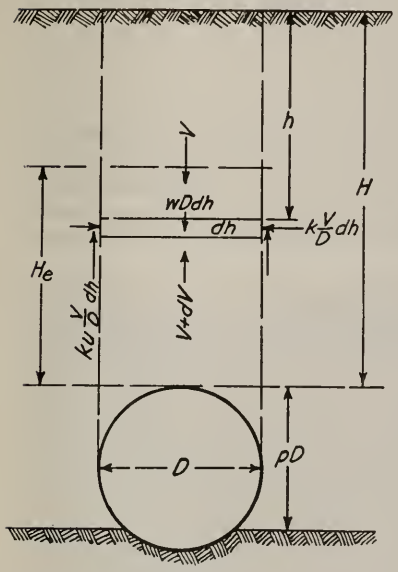


Fig. 2

In Fig. 2 the forces shown acting on the segment of thickness dh are the same as in Fig. 1 except the direction of the friction has been reversed.

Case I, H Less Than H_e

$$dV = wD\ dh - 2\ ku \frac{V}{D} dh \quad \text{.....(p)}$$

$$\frac{dV}{wD - \frac{2ku}{D} V} = dh \quad \text{.....(q)}$$

Solving,

$$\log\left(wD - \frac{2\,ku}{D} V\right) = \text{constant} - \frac{2\,ku}{D} h \quad \text{.....(r)}$$

When $h = O$, $V = O$,
Therefore constant $= wD$.

Then

$$\log\left(wD - \frac{2\,ku}{D} V\right) = \log wD - \frac{2\,ku}{D} h \quad \text{.....(s)}$$

$$\log\left[\frac{wD - \frac{2\,ku}{D} V}{wD}\right] = -\frac{2\,ku}{D} h \quad \text{.....(t)}$$

$$\frac{wD - \frac{2\,ku}{D} V}{wD} = \frac{1}{e^{2ku\frac{h}{D}}} \quad \text{.....(u)}$$

At top of culvert $h = H$ and $V = W_e$

Transposing

$$W_c = \frac{1 - \dfrac{1}{e^{2ku\frac{H}{D}}}}{2\,ku} wD^2 \quad \text{.....(v)}$$

Or, $W_c = C_t\, wD^2$ .....(5)

$$\text{Where } C_t = \frac{1 - \dfrac{1}{e^{2ku\frac{H}{D}}}}{2\,ku} \quad \text{.....(6)}$$

Equation (v) is the same as the formula for the load on pipes in ditches as given by Dean Marston on page 33, Bulletin 31, Iowa State College Experiment Station; it is also practically the same as Janssen's formula for pressure in deep bins except in this case the frictional forces are acting on the two opposite sides of a prism instead of on the perimeter of a bin.

Case II, H Greater Than H_e

Let the notation be the same as in Case II, Type I.

Then,

$$dV_h = -2\,ku\frac{V_h}{D}dh \quad \text{.....(w)}$$

Following the same steps as in the solution in Case II, Type I,

$$\log\frac{V_h}{(H - H_e)wD} = -\frac{2\,ku}{D}h \quad \text{.....(x)}$$

$$V_h = \frac{(H - H_e)wD}{e^{2ku\frac{h}{D}}} \quad \text{.....(y)}$$

At the top of the culvert $h = H_e$ and $V_h =$ the addition to W_c due to the embankment materials above the level H_e.

Therefore,

$$W_c = \frac{1 - \dfrac{1}{e^{2ku\frac{H_e}{D}}}}{2\,ku} wD^2 + \frac{(H - H_e)wD}{e^{2ku\frac{H_e}{D}}} \quad \text{.....(z)}$$

Or,

$$W_e = C_t w D^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$C_t = \frac{1 - \dfrac{1}{e^{2ku\frac{H_e}{D}}}}{2ku} + \frac{H - H_e}{D\, e^{2ku\frac{H_e}{D}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

To Derive a Formula for Computing H_e for Type II

Referring to our definition of H_e it is readily seen that, since V_h is less than the stress in the adjacent prism, and H_e is less than $(H_e + pD)$, it is impossible to equate these products. This is because the large deflection of the culvert causes V_h to be less and this deflection must be included. For this reason E will not disappear from the equation, which somewhat destroys its practical value.

This derivation is the same as in Type I except the quantity d_1 will have to be introduced.

d = deflection of culvert at height H.
d_1 = deflection of culvert due to filling materials above height H_e.

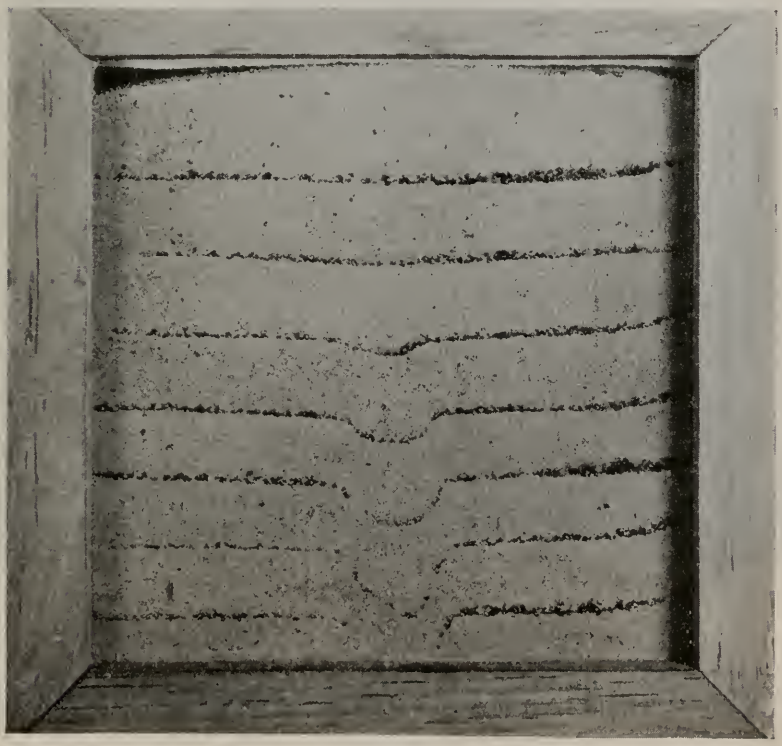


Photo 1

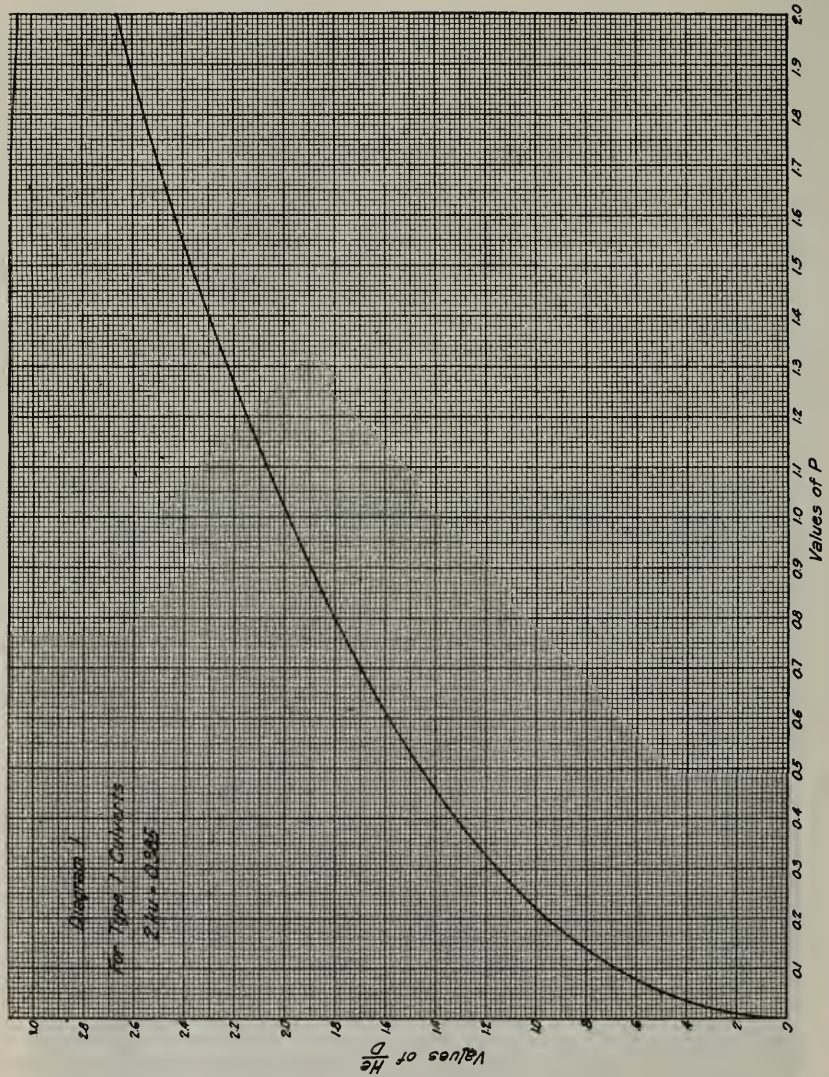


Diagram 1
For Type 1 Culverts
Values of P
Values of He/D

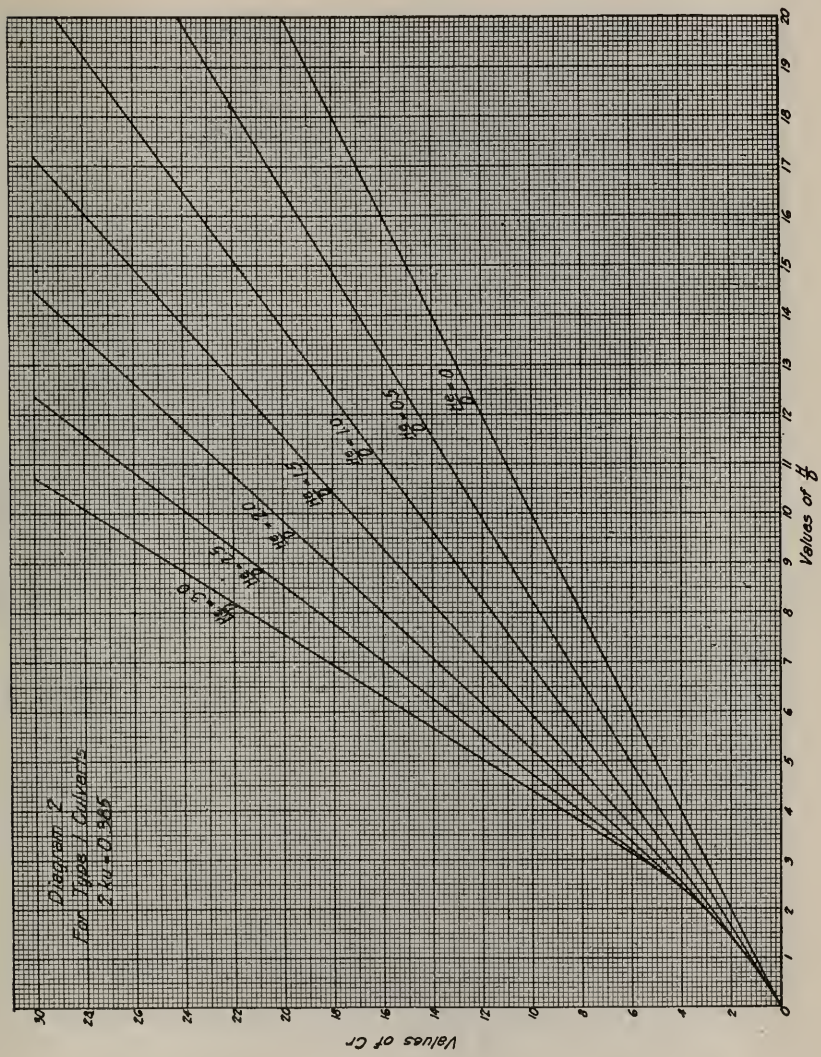


Diagram 2
For Type 1 Culverts
2 ku = 0.385
Values of Cr
Values of H/D
He/D = 0
He/D = 0.5
He/D = 1.0
He/D = 1.5
He/D = 2.0
He/D = 2.5
He/D = 3.0

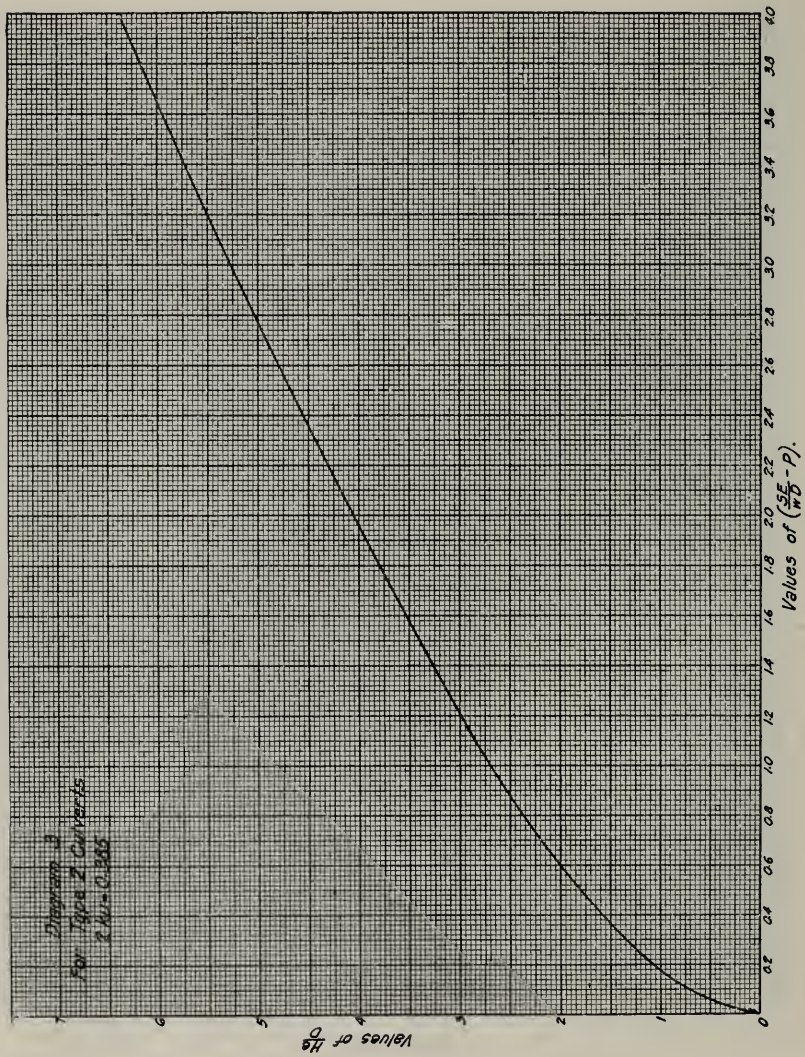


Diagram 3
For Type 2 Culverts
2 ku = 0.385
Values of $\frac{He}{D}$
Values of $\left(\frac{SE}{wD} - P\right)$.

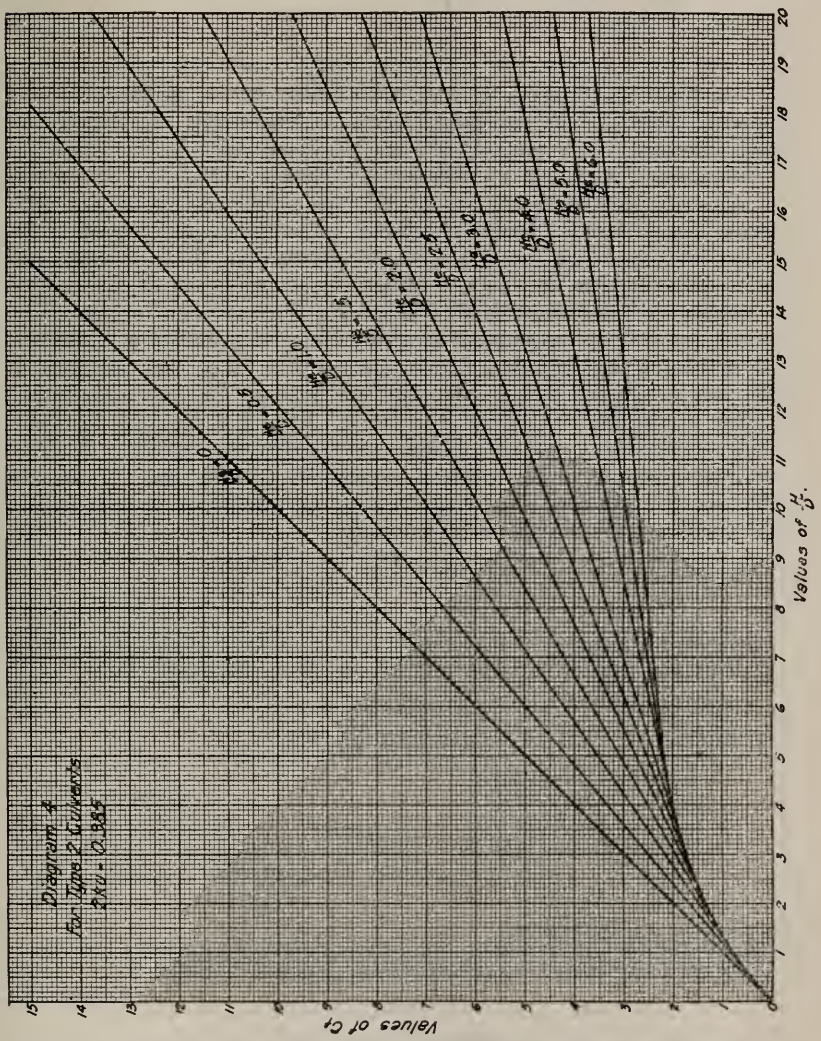


Diagram 4
For Type 2 Culverts
2ku = 0.385
Values of C_f
Values of $\frac{H}{D}$.

$$\frac{(H-H_e)w}{E}(H_e+pD)=\int_O^{H_e}\frac{\frac{V_h}{D}}{E}dh+d_1 \quad \text{(A)}$$

In the previous report this Committee stated that the deflection of corrugated culverts is an exponential factor of the height of embankment. This exponent varies greatly for different filling materials and also produces a very complicated formula for the solution of H_e. At a conference in Chicago with representatives of the Committee on October 28, 1927, Dean Anson Marston, Iowa State College, Ames, Iowa, showed them his recently developed solution for a general equation for H_e for flexible culverts, including also the effect of settlement of culvert and of subgrade of embankment. Dean Marston showed them a single diagram for convenient calculation of loads on both rigid and flexible culverts, including the effects of settlement and deflection. Dean Marston also called their attention to the fact (from which they could derive a solution for H_e corresponding closely to his) that the deflection curves in Charts 3, 4 and 5 of this Committee's 1926 report (Vol. 27, Proceedings A.R.E.A., pp. 815-817) show that the upper portions of the curves are essentially straight lines. A straight line can be drawn very close to all deflection readings above the point where the pressure readings indicate H_e is located.

Therefore, for the deflection above H_e,

$$d=(H-i)S \quad \text{(B)}$$

where i is the intercept of this straight line on the vertical axis and $S=$ the slope of this straight line with reference to the vertical axis. Then,

$$d_1=(H-H_e)S \quad \text{(C)}$$

Substituting (C) and (y) in (A) and arranging,

$$H_e+pD=\int_O^{H_e}\frac{dh}{e^{2ku\frac{h}{D}}}+\frac{SE}{w} \quad \text{(D)}$$

Integrating and arranging,

$$e^{-2ku\frac{H_e}{D}}+2ku\frac{H_e}{D}=1+2ku\left(\frac{SE}{wD}-p\right) \quad (8)$$

Diagrams 1 and 3 give values of $\frac{H_e}{D}$ for various values of p and $\left(\frac{SE}{wD}-p\right)$. Diagrams 2 and 4 give values of C_r and C_t for various values

of $\frac{H_e}{D}$ and $\frac{H}{D}$. These four diagrams could be combined into one, eliminating the solution of $\frac{H_e}{D}$, but the Committee considered it advisable to give them in the present form as they can be more readily identified with the mathematical theory. Also, at the present stage of the Committee's work, it is desirable to solve for H_e to compare with the shape of deflection and load curves, so for that reason Diagrams 1 and 3 are required to be shown separately. The value of $2ku = 0.385$ has been used in these diagrams, corresponding to $u = 0.52$. The error will be very slight if these diagrams are used for any angle of internal friction between 22° and 40°. The curved part of Diagrams 2 and 4 gives values of C_r and C_t when H is less than H_e.

Application of Above Formulas to Farina Tests

The Committee has made the following calculations on the Farina installations.

Line No. 6, 42-Inch Castiron Pipe. H = 34.2′

$k = 0.37$. $u = 0.52$. Outside diameter = 44.5″ or 3.7′. $p = 0.8$.

From Diagram 1, $\frac{H_e}{D} = 1.8$.

$\frac{H}{D} = 9.25$, from Diagram 2 $C_r = 17.57$.

$W_c = 17.57 \times 105 \times 3.7^2 = 25{,}300$ lb.

Average = 47.4 lb. per sq. in.

Top cell reading = 35.3 lb. per sq. in.

Weight of earth = 25.0 lb. per sq. in.

Line No. 6, $H = 14.7'$. $\frac{H}{D} = 3.97$

From Diagram 2, $C_r = 6.93$.

$W_c = 6.93 \times 96 \times 3.7^2 = 9{,}120$ lb.

Average = 17.1 lb. per sq. in.

Top cell reading = 11.98 lb. per sq. in.

Weight of earth = 9.8 lb. per sq. in.

If the nominal diameter is used rather than the outside diameter the average unit pressure obtained will be almost identical with the value obtained above.

Corrugated Culverts

In using Formula (8) it is necessary to have the value of E and the slope of the upper portion of the deflection curve. When the data from other tests now being made are available the Committee expects to obtain an empirical coefficient to use in place of $\frac{SE}{wD}$ in this formula, which coeffi-

cient will also include the difference in the settlement of the foundation under the culvert and under the adjacent fill. In applying Formula (8) to the Farina tests the Committee has used the slope of the actual deflection curve and endeavored to obtain a fair value of E.

The E desired for this formula is the stress strain ratio or the unit stress divided by the total unit deformation. The Committee had the modulus of elasticity of the embankment materials determined by the Bureau of Public Roads. Their standard test defines this modulus as the rebound which occurs upon the removal of the load. In making the test a specimen one inch in diameter and approximately one inch in height was cut from the soil and, while confined laterally, was first subjected to a vertical load of 3 kg. per sq. cm. for two days, and then was allowed to soak up water for two days without load. The modulus of elasticity, as determined by the Bureau, was 130 kg. per sq. cm. for the top soil used in the first eight feet of embankment and 150 kg. per sq. cm. for the clay that was used for the larger part of the remainder of the fill. The ratio of the rebound to the total deformation of these soils was 0.126 and 0.177, respectively. These moduli have to be multiplied by these ratios to obtain the value of E as needed in the formula. The value of E for these soils would then be 16.4 and 26.5 kg. per sq. cm.

The Committee feels that, due to the nature of the test, and due to the fact that the soil was not in the same condition when tested as it is in the fill, these values are not very close to the values that would be obtained if the soil were tested in its natural state. They are probably lower. The Committee has not had time to have other tests made in line with their needs, so in the absence of something better, these values have been used. As H_e extends into the clay it is necessary to use both moduli. In some of the calculations the greater portion of H_e occurs in the top soil and in some the larger portion is in the clay. Using approximate values of H_e as indicated by the pressure and deflection curves, the greater portion of H_e will be in the clay. As great refinement is not here warranted, the Committee used the same value of E for all calculations and obtained it by averaging the two values above. Reducing to proper units this is 43,900 lb. per sq. ft.

The diameter used is the nominal diameter of the culvert increased by the horizontal deflection obtained in the tests.

Line No. 5, 42-Inch Corrugated Culvert. $H = 33.5'$.

Other data same as for Line No. 6 except $p = 0.65$. $D = 3.74'$. $\frac{H}{D} = 8.95$.

$S = 0.0101$.

$$\frac{SE}{wD} - p = \frac{0.0101 \times 43{,}900}{105 \times 3.74} - 0.65 = 0.48.$$

From Diagram 3, $\frac{H_e}{D} = 1.76$.

From Diagram 4, $C_f = 4.97$.
$W_e = 4.97 \times 105 \times 3.74^2 = 7{,}300$ lb.
Average $= 13.54$ lb. per sq. in.
Top cell reading $= 13.0$ lb. per sq. in.
Weight of earth $= 24.5$ lb. per sq. in.

LINE NO. 7, 42-INCH CORRUGATED CULVERT. $H = 15.4'$.

$p = 0.8$. $D = 3.56$. $\frac{H}{D} = 4.33$. $S = 0.009$.

$$\frac{SE}{wD} - p = \frac{0.009 \times 43{,}900}{98 \times 3.56} - 0.8 = 0.332.$$

From Diagram 3, $\frac{H_e}{D} = 1.44$.
From Diagram 4, $C_f = 2.78$.
$W_e = 2.78 \times 98 \times 3.56^2 = 3{,}460$ lb.
Average $= 6.75$ lb. per sq. in.
Top cell reading $= 8.9$ lb. per sq. in.
Weight of earth $= 10.5$ lb per sq. in.

LINE NO. 8, 48-INCH CORRUGATED CULVERT. $H = 31.6$.

$p = 0.8$. $D = 4.27$. $\frac{H}{D} = 7.4$. $S = 0.0163$.

$$\frac{SE}{wD} - p = \frac{0.0163 \times 43{,}900}{105 \times 4.27} - 0.8 = 0.795.$$

From Diagram 3, $\frac{H_e}{D} = 2.36$.
From Diagram 4, $C_f = 3.60$.
$W_e = 3.60 \times 105 \times 4.27^2 = 6{,}900$ lb.
Average $= 11.2$ lb. per sq. in.
Top cell reading $= 12.5$ lb. per sq. in.
Weight of earth $= 23.1$ lb. per sq. in.

The settlement of the culvert into the foundation has not been included in the above. While the Committee has some readings on the settlement of the culverts it has no information on the settlement of the foundation under the adjacent embankment. The difference between these two settlements is required and this is probably very small. In any case there is less error in ignoring both than including one and ignoring the other.

Summary

It is to be expected that the calculations for the castiron pipe will give results greater than those from the tests. The formulas are based on the supposition that there is no deflection of the culvert. If the small deflection is

introduced in the calculations, replacing p by $\left(p - \frac{SE}{wD}\right)$, the calculated pressure will be reduced a small amount.

The agreement between the calculations and the tests for the corrugated culverts is remarkably close, particularly in view of some of the assumptions it was necessary to make. If a larger value of E is used, which the Committee believes would be nearer the correct one, or a value of H_e near to the value indicated by the pressure and deflection curves, the calculated pressure will be reduced so as to be below the cell readings in all cases so far calculated.

If the distribution of the unit vertical pressure varies very much from the average it will modify the above formulas somewhat. The unit pressure at the center is probably a little greater than the average. The Committee expects to go into this phase before the time of its next report.

Diagrams 1 to 4 will not need to be changed when the empirical coefficients are determined. It will only be necessary to substitute the values of these coefficients for the values of p and $\left(\frac{SE}{wD} - p\right)$ in Diagrams 1 and 3.

The Committee is now considering deflection and moment formulas as applicable to corrugated culverts. Its next step will be to study the side pressures in connection with the vertical pressures and supporting strength of the pipe itself at different deflections. The Committee will then be ready to specify allowable deflection and recommended gages.

Appendix C

(3) DEFORMATION OF THE ROADBED

Jamison Vawter, Chairman, Sub-Committee; H. B. Barry, W. G. Brown, F. L. Guy, F. W. Hillman, H. E. Tyrrell, W. D. Wiggins.

The points considered in the Committee's work on the above subjects were: what depths of ballast give particular trouble, difference in maintenance cost for deeper ballast sections, maintenance costs in wet cuts or other places of poor foundation, and suggested remedies. Among the remedies considered were: drainage, deeper ballast, and concrete slabs.

Adequate drainage is the most important requirement for a railway roadbed and is very essential in the treatment of wet cuts and water pockets. Where the cost is not prohibitive the roadbed should be prepared by the removal of all inferior subgrade material and replaced with a better material applying at least 12 inches of high-class ballast. Where this cannot be done it would be necessary to use some method of subgrade drainage to give relief.

Water pockets in cuts are in most cases natural, those in embankments are artificial and are caused by the sealing up of the outlet drainage after the roadbed has become depressed under the rails by the continued application of loads. Water pockets in cuts may be remedied by providing outlet drainage below the bottom of the pockets and proper cross drainage. In embankments they will have to be tapped, either by driving pipe through the side of the embankment, laying drain tile, or by digging trenches from the side and back-filling with rock. Driving piling sometimes proves successful. In cuts they should be driven deep enough to permit the water to escape through the impervious strata that holds it.

In studying the effect of deeper ballast the following pressure was obtained from a report of the Special Committee on Stresses in Railroad Track (Vol. 21, A.R.E.A. Proceedings, pages 778 to 814) 6-inch by 8-inch by 8-foot cross-ties spaced 21 inches with 12 inches of ballast. The loading used was an E-60 locomotive. Allowing 50 per cent impact the maximum pressure at the bottom of the ballast was 6300 lb. per sq. ft. The report of the Special Committee indicated that for a depth of ballast of 24 inches the weight of the locomotive would be uniformly distributed over the foundation.

In the 1927 report of the Roadway Committee (Vol. 28, Proceedings A.R.E.A., page 863, Fig. 9) there is shown a section of an 8-inch plain concrete slab used by the Long Island Railroad Company. This company installed about 73,000 sq. ft. of this slab in 1912 under slip switches, frogs and crossings on a 22-ft. embankment. There is a train movement of about 1200 trains daily through the yard. The company reports that in the 15 years since they were installed there was no frog or switch renewal until last year when one slip switch was changed. The slabs have cost nothing since they were installed and track work has cost very little. They have since put these slabs in at other points, and particularly on soft ground where they have served the purpose for which they were intended, *i. e.*, to prevent track settling.

If a concrete slab were placed under the 12-inch ballast section, properly

designed to care for the distribution of pressure figured above, a six-inch mesh reinforced slab or an 8-inch plain concrete slab would be required. This would cost roughly $4.50 per ft. of track on new construction and considerably more on old track. Twelve inches of additional ballast could be placed at about $1.25 per ft. of track.

The use of concrete slabs under existing track as a remedy for roadbed deformation is somewhat questionable, partly due to the cost and also since the track will have to be withdrawn from operation during the period required for the curing of the concrete. On the basis of the above costs it appears that, in general, roadbed deformations may best be eliminated by, first, preparing the roadbed to stand a reasonable load and, second, applying such a depth of ballast as would so distribute the load applied that the pressure per square foot would not be greater than the capacity of the roadbed. In certain bad spots the use of the slabs might be a desirable remedy.

It will be necessary to have comparative maintenance costs for different ballast sections and various foundation conditions in order to make proper comparison of the above. The Committee was unable to obtain sufficient information from its own personnel. It is now the intention of the Committee to try to obtain this information by means of a general questionnaire.

Appendix E

(5) CONTINUE THE STUDY OF SPECIFICATIONS FOR STEEL FENCE POSTS

A. E. Botts, Chairman, Sub-Committee; H. A. Dixon, J. S. Goodman, W. C. Morris, E. M. Smith, J. R. Wilks.

Introduction

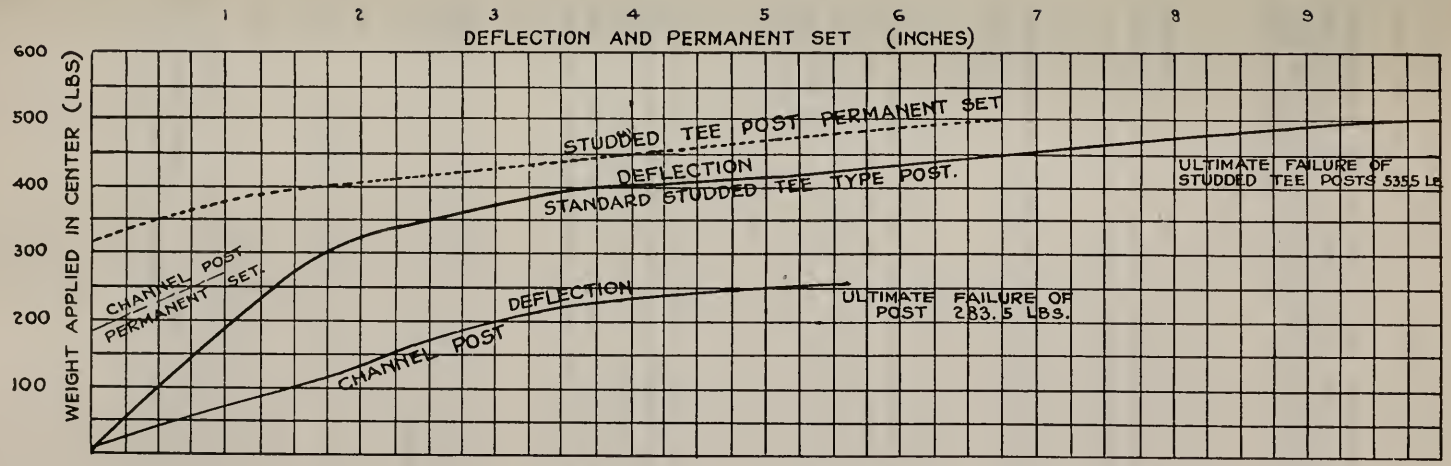
The Committee was instructed to continue the study of specifications for steel fence posts, but after going into the subject thoroughly, deemed it proper to elaborate upon same sufficiently to include iron posts in the specifications. In our endeavor to establish the extent to which steel posts are used by various railroads, we find from data assembled, the use thereof limited, but the tendency being toward greater use. Many roads have only a few for test purposes, some of which had not been in use long enough to make report one way or the other.

History

We have record of galvanized angle iron posts installed in 1880 along the N.Y.N.H.&H.R.R. which are in excellent condition today. Analysis of these posts as follows:

Carbon	0.03
Manganese	0.017
Phosphorus	0.200
Sulphur	0.026
Silicon	0.18
Copper	0.019

We also have record of metal posts yet in good condition, which were erected by the Chicago, Pekin & Southwestern Railway between Joliet and



STUDDED TEE POST. CHANNEL POST

WEIGHT	DEFLECTION	PERMANENT SET	DEFLECTION	PERMANENT SET
31.5	3/16"		3/16"	0
63	3/8		1	Z
94.5	9/16	0	1-3/8	I
126	11/16	I	1-7/8	F
157.5	7/8	–	2-3/8	0
189	1-1/16	I	2-7/8	I
220.5	1-1/4	F	3-3/8	7/16
252	1-7/16	0	5-3/8	13/16
283.5	1-5/8	I	ULTIMATE	FAILURE
315	1-7/8			
346.5	2-3/8	3/8		
378	3-7/16	1-3/16		
409.5	4-7/8	2-3/8		
441	6-3/8	3-3/8		
472.5	7-15/16	5-3/16		
504	9-3/4	6-7/8		
535.5	ULTIMATE FAILURE			

TESTS MADE ON METAL FENCE POST
RICHMOND, VA. JULY 19, 1926.

Plaines, Illinois, in 1886. These posts were set in rock and wedged with metal spikes. The only weakness that has appeared in these posts is the method of fastening the wire, which was done by using a part of the post, which was crude and would have been better had holes been bored for wire fasteners.

Types

Various types of metal posts are manufactured and used, some of which are the Tee, Ell, Wye, Channel and Tubular sections. Of these, the types most used by railroads are of the tee and the tubular patterns.

Advantages

Metal fence posts are easy to install and their use eliminates fire hazards, reduces drifting of snow because of the fence, gives better appearance, and probably is economical.

Strength

The chart given herewith shows the results of the only tests of which we were able to secure information, but even with this meager data it is evident that there is no lack of strength for the purpose for which they are used, of good metal fence posts. It will be noted that one of the posts, covered by the test chart, failed at 283.5 pounds, while the other failed at 535.5 pounds, applied at the center with the post supported at the ends.

Application

Except where set in concrete bases, the application of metal fence posts is less expensive than that of wooden posts. The application of metal fence posts is particularly advantageous in rocky regions where a fair sized drill hole is sufficient to receive the metal post, but where blasting must be resorted to in order to make a post hole large enough for wood or concrete post.

General

The Committee submits the following specifications for metal fence posts, which it believes will insure a post which will prove satisfactory both as to strength and durability.

SPECIFICATIONS FOR METAL FENCE POSTS

Classes

Metal fence posts shall be divided into two classes:

(1) Posts which support the straight away body of the fence shall be designated as "line posts."
(2) Such other special posts as are needed at the end or corner of the fence and at gates, shall be designated as "end, corner, and gate posts."

Material

To avoid rust as far as possible, the material of which fence posts are made should be either—pure iron, copper-bearing iron, copper molybdenum iron, or copper-bearing steel.

NOTE.—Analyses of these metals can be obtained from the Bureau of Public Roads, U.S. Dept. of Agriculture.

Strength

Material used for fence posts shall have a minimum tensile strength of 40,000 lb. per sq. in., and shall have a gross load strength of not less than 500 lb., applied at the center of the post, with supports three feet each way from the center. The load for this test shall be applied to the face of the post against which the fence material bears.

Ductility

Test pieces of the finished posts, with the exception of tubular posts, shall bend cold around a mandrel of a radius equal to twice the dimension of the post at right angles to the mandrel, through 90 degrees without fracture of the material.

TUBULAR POSTS TEST.—The cold rolling of tubular posts is sufficient test for ductility.

Workmanship

All posts shall be smoothly rolled or formed and shall be straight throughout the length. Each finished post shall be free from burrs or other deformation caused by fabrication. They shall also be free from slivers, depressions, seams, crop ends and evidence of being burnt.

(The above does not refer to rough places caused by zinc coating when galvanized.) Variations in length shall not exceed ½ inch. Variations in other dimensions shall not vary more than $\frac{1}{16}$ inch.

Coating

ZINC.—All galvanized posts shall be galvanized by the hot dip process and shall possess a uniform coating of prime Western spelter or better grade with not less than two ounces per square foot of surface as determined by the spot test or by the Preece Test with four dips.

Galvanized posts are to be desired. All posts not galvanized shall be painted or dipped in a protective coating of metallic paint.

Special Fabrication for Line Posts

Line posts shall be fabricated to the section agreed upon by the purchaser.

If the posts are not so designed as to make anchorage for alinement unnecessary, an anchorage device shall be rigidly fabricated to bottom portion of posts.

All posts shall be provided with some convenient means of fastening wire to same for at least 12 positions in a height of five feet, above the

surface of the ground. All posts shall permit the refastening of the wire at least five times without damage to the connecting appliance, if an integral part of the post.

All posts shall be capable of being driven in ordinary earth without injury to the post.

All posts shall have sufficient length so that when installed with the required height above ground, one-third of the total length shall be underground, providing that the post shall extend into the ground not less than 2½ feet.

Special Fabrication for End, Corner and Gate Posts

All special posts shall be fabricated the same as line posts, except as follows:

All posts shall have sufficient length to permit installing 3 ft. 0 in. into the ground.

All posts shall be equipped with some suitable form of bracing and anchorage which shall aid in keeping the post vertical.

Weight

The main stem of all form sections not including tubing shall weigh at least 1.40 lb. per linear foot. Posts made of tubing shall be fabricated of at least ten gage material and not less than 1¾ inches in diameter.

Inspection

Inspection and approval of the posts shall be made by the Engineer or other authorized representative of the purchaser. Such inspection shall be made at the plant of the manufacturer, who will allow the inspector access to all operations involved and shall facilitate as much as possible the work of inspection and provide necessary facilities for inspection. Two posts out of each 200, selected at random by the inspector, shall be inspected and tested and if they meet the requirements, the lot shall be accepted. If either fails to meet requirements, three other posts shall be selected in like manner by the inspector and if either one of these shall fail, the lot shall be rejected.

Appendix F

(6) PERMANENT ROADBED

E. J. Bayer, Chairman, Sub-Committee; Paul Chipman, M. H. Doughty, A. A. Johnson, C. B. Harveson, W. A. Murray, W. D. Wiggins.

The subject assigned is "Continue the Study of Permanent Roadbed," collaborating with Committee V—Track.

The instructions to collaborate with Committee V are undoubtedly due to subject No. 5 as assigned to that Committee, which reads, "Study and report on design and specifications for foundations under railway crossings," etc.

As permanent roadbed and foundations under crossings are or may be very similar in construction, conflicting reports might easily be made if each committee acted alone, therefore Committee V was requested to designate a Sub-Committee to work with Committee I on this subject and the following members were assigned to that Sub-Committee by Chairman Neubert:

Collaborating Sub-Committee of the Track Committee: E. R. Lewis. Chairman; W. H. Bevan, F. S. Hales, J. C. Mock, G. J. Slibeck.

The two Sub-Committees are therefore making a joint report, as follows:

REPORT OF COLLABORATING COMMITTEE 8 OF COMMITTEE V—TRACK

It is understood that the object of consideration of this assignment is to determine what design of track and track foundation will most suitably and economically carry railway traffic. Most designs suggested to date include alterations in the track structure as well as the roadbed, notably the rail fastenings. Increasing loads demand stiffer track members as well as more permanent roadbed. Track failures are largely due primarily to poor drainage of the track foundation. This fault may be in the ballast, the roadbed and/or the foundation on which the roadbed rests. It is believed that drainage is the first and most important structural requirement for a railroad track and roadbed; that the fullest consideration and best possible treatment should be given to drainage preferably before the roadbed and track are built; that attractive returns on such an investment are invariably realized from the beginning; and that cost items of labor and materials of track maintenance, as well as maintenance of equipment and cost of operation, greatly benefit as a result of proper drainage.

In consideration of permanent roadbed the degree of permanency desirable in the structure of the track and its foundation is a matter for debate. Any disturbance of the soil under a roadbed of permanent construction, especially if elevated on an embankment, would be more disastrous than a similar disturbance under rails laid on wood ties and ballast. Replacement would be slower and more expensive. It is frequently desirable to shift tracks, to introduce or eliminate turnouts, to alter the levels of the roadbed and tracks, etc. Furthermore such alterations are not always subject to the sole discretion of the owner companies, but are made on insistence of public authorities, being frequently incidental to public improvements which are sometimes outside of the realms of transportation. It is suggested that permanence of location should be assured as a second prime requisite for consideration of permanent roadbed. To be useful a roadbed preferably should be built on a stabilized foundation.

Various degrees of roadbed permanency have been attained where necessary to build and operate railroads through swamps, wet cuts or other natural formation of insufficient bearing power. The means employed in construction, such as log corduroy, mattresses of saplings, sawed timber floors on mud sills or pile trestles, etc., are frequently improved or replaced during the operating period as necessity demands with a view to minimizing maintenance costs and supporting increased axle loads.

Pile foundations are sometimes necessary in wet cuts through quicksand, muskeg, etc., which could only be drained at great expense. The floor may be of close laid sawed timber or reinforced concrete slabs on which the ballasted track is laid. Local conditions usually necessitate special treatment for individual cases.

Both expedients are employed by the New York Central in the vicinity of Poughkeepsie, New York, and Staatsburg, the concrete slabs being

built below subgrade level and between limiting lines of sheathing driven parallel with the rails, while the timber floors rest on 12 ft. caps of 4 or 5 pile bents driven for spans of 12 ft. lengths center to center. Cost of slab foundations vary from $6.70 to $9.30 per linear foot of single track, while the trestle cost $15.50 per linear foot of single track. Both unit cost figures include all expense involved in excavation and disposal of earth, placing of cinders, etc.

The foremost material of construction considered in designs of permanent roadbed is reinforced concrete. Designs vary with the theories of the desirability of more or less resiliency to that of absolute rigidity in the structure, the former seeking in some measure to distribute the loads through the track members and ballast to the concrete slab, while the latter provides for concrete foundation directly supporting the rails. While the placing of a permanent foundation beneath the ballast permits the continued use of standard ballasted track with wooden ties or some modification thereof, the rigid type of rails-on-concrete eliminates both ties and ballast, and necessitates some design of rail fastening suitable to steel on concrete with provision for insulation. A modification of such a design tending toward simplicity is the introduction of short wood ties or blocks partially embedded in the concrete slab. Short stretches of such track have been in service in stations, tunnels, etc., for a considerable time with satisfactory results.

Examples of rigid street car track foundations in service are those at Bridgeport, Connecticut, and Detroit, Michigan. In these cases the rails and steel ties are first laid on a concrete base, after which a course of concrete is added between and outside the rails to the level of the top of rail, this last course being thoroughly compacted by repeated application of a steam roller. It has been found that the renewal of rails or foundations in such cases are comparatively expensive, though necessary only at infrequent intervals. Reference is made to the 1927 report of the Roadway Committee and the suggested design for standard concrete railway track support, Fig. 22, bottom of page 870 Bulletin 295 of March, 1927, and the following text entitled "Economic Considerations." A rail chair partially embedded in the concrete instead of the "U" bolts with clips which are a part of this design is perhaps worthy of consideration as a fastening of known excellence.

Experience indicates that the greatest care is required to prevent settlement of foundation slabs of concrete even when the supporting soil has been reasonably drained. Inequalities occur through the unequal though gradual drying and shrinkage of the ground beneath the slab, as well as through conditions resulting from high water, heaving from frost in winter, etc. While a concrete foundation for the rails may eliminate ties and ballast with the attendant costs of maintenance and renewals thereof, the maintenance of surface of a track on such a roadbed is likely to prove both difficult and expensive. If on the other hand the concrete slab is laid as a floor for ballast, surface is more readily maintained, but the faults in design of the present track are not corrected, while the permanent foundation will largely increase the first cost of track without greatly reducing maintenance and renewal expense.

One railway company reports experimental sections laid in a well drained gravel cut some 13 years ago. The best of these types consists of a concrete slab 8 ft. wide and of a minimum thickness of about 14 in., laid on a bed of 9 in. of rock ballast. In the concrete are set two longitudinal 3 in. by 6 in. timbers under each rail carrying 6 in. by 8 in. by 24 in. tie blocks fastened with drift bolts. These tie blocks spaced 11 in. center to center, support the 90-lb. rails on ½ in. by 7 in. by 9 in. tie plates with screw spike fastenings. Panel openings between ties are specially drained and filled with gravel. This type, which costs at the rate of over $45,000 per mile, kept good line and surface for six years. The average cost of maintenance over a period of some seven years was $1510 per mile as against an average of $1300 to $1500 per mile for adjacent standard gravel

ballasted track on 8 ft. wood cross-ties. Maintenance of line and surface has been effected through shimming and renewals of tie blocks, no corrections having been made in the slab. A somewhat similar section laid on a fill was removed because of settlement. In the opinion of the Chief Engineer "the construction is very expensive and would be entirely impracticable for general use on high or low fills where substantial settlement would be likely to occur."

Another similar design is that of the Detroit River Tunnel tracks of the Michigan Central laid in 1910. In this case a longitudinal open gutter occupies central spaces between double track. Short untreated soft wood cross-ties were laid on the concrete floor of the tunnel to support the tie plates and rails. After laying the track, concrete was poured between and around the outer ends of the ties to a height of from two to three inches below top of tie. There are no tie rods or other device to hold the rails to gage. This track has given no trouble to date. The maintenance compares favorably with standard track on ballast and 8 ft. ties. The short soft wood ties in the tunnel absorb enough moisture to keep them tight in the concrete. No tight gage has ever resulted and no ties have been removed due to causes other than mechanical wear. The rail wears somewhat faster than rail on ballasted track, due in part to heavy traffic and grades.

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In the report appearing in the 1927 Proceedings, page 852, a history of this subject was given and specific mention made of installations of permanent character.

The Committee this year has been endeavoring to develop information as to whether or not the types so far used will be able to justify their continued use by proving conclusively that they require less maintenance.

The railways experimenting with a type of permanent roadbed were canvassed and it was found that no data was available or maintained which could be compared with a stretch of track in the same locality, of the ordinary type of construction.

The New York Central and Pere Marquette are, however, starting to keep costs on their respective types of construction and the Committee is of the opinion that by next year it will be in a position to give comparative costs for one year at least. It is also the expectation that the railroads will continue to furnish this information from year to year so that definite conclusions may be reached as to the advisability of continuing the type developed by them and afford a means of comparison between the different types developed. Further attempts will also be made to secure information from the other roads which are now experimenting along the same lines.

The Committee made an inspection of the installation on the Pere Marquette during August and the following is given as to conditions existing at that time:

Concrete:	No signs of failure.
Line:	Not very good owing to the difficulty of aligning the bolt holes for the rail clips. If this type of track proves economical, a form of adjustable fastening must be developed.
Surface:	Fair. Probably a part of the roughness is due to the insulating pads.
Insulation:	The insulation placed under the rails throughout their entire length has crushed and squeezed out, allowing the rail to bear directly on the concrete. Some signal failures have also been noticed during wet weather.
Expansion:	With the air at a temperature of approximately 80 degrees no joints were noted in which the expansion had not been lost.
Creeping:	A tendency was also noted towards creeping.

A more detailed report on the present installation is given by Mr. Chipman in the following report, which was prepared subsequent to the Committee's inspection:

"Operation began over the concrete roadbed December 19, 1926. Up to the present time there has been no expense in connection with it which is properly charged to maintenance. The material which was originally placed under the rails proved to be unsatisfactory and has been removed. This has resulted in some signal trouble in wet weather, and it is the intention to place insulating fiber under one rail for the entire length of the concrete. This material has been ordered and will be put in place within the next thirty days. This change will result in some expense, which under accounting regulations would be charged to maintenance, but inasmuch as the entire project is experimental it does not seem to me that such expense is what our sub-committee should report as maintenance. Aside from this feature there has been no maintenance expense to date on this work.

"In regard to the concrete roadbed, aside from the insulation feature, it is in practically the same condition as when operation started. It rides very smoothly, as it has from the start. Three very fine cracks which extend through the slab at right angles to the track have developed; one of these is in the first 30 foot section placed, and is a construction joint caused by this section not having been finished the first day. Level readings taken at these cracks do not indicate any unequal settlement.

"One of the most interesting things about this installation is the fact that the entire section has settled about an inch. This settlement is uniform transversely. That is, it has caused no appreciable difference in the relative elevation of the two rails at any point. The least settlement when levels were last run was .03 of a foot and the greatest .12, and the change between is gradual. The subgrade consisted of as much of the original gravel ballast as lay beneath the old ties. Under this was the original subgrade of sand and sandy loam. Most of the section was on a shallow fill not exceeding three feet in depth, but a small part of it was in a shallow sandy cut. The old roadbed had been in service nearly three years, and it is scarcely probable that any more compression took place in it and in the ballast after the concrete slab was placed above them. My idea is that the entire roadbed has been driven into the ground. We know that this action takes place in ordinary track on shallow fills, but it would hardly be expected to continue under a solid concrete slab. The evidence indicates, however, that it has. About half of this settlement took place in the first two weeks after operation began, about half of the remainder within the following six weeks and the balance within the next following two months, or about four months after operation began. Since that time there has been no appreciable settlement.

"The wear of the rail at the joints appears to be proceeding at about the same rate as in the ordinary track adjacent—certainly not any faster. There is as yet no conclusive evidence of wear in the concrete beneath the rail, that is, of the rail cutting into the concrete. At several rail joints we have suspected that something of the kind might be taking place; but if it is, the amount is so small that it cannot yet be measured. Those places will be kept under observation in order to determine whether such wear is actually taking place or whether it is our imagination.

"Creeping of the rails has caused no trouble. The rails are well anchored to the ties for some distance each side of the test section. The maximum creeping on the concrete this summer was about two inches near the center of the quarter mile section."

One other railway which has a test section of permanent roadbed was approached for information. They, however, took the position that if the railroads were not enough interested in what they were doing to send representatives to go over their experimental section, that they did not think a report on what they were doing would prove of any use in benefiting railroad construction or maintenance.

The Committee recommends that this report be accepted as information and that the subject be continued.

Appendix G

(7) PROPER METHODS FOR POLICING RIGHT-OF-WAY, WITH SPECIAL REFERENCE TO APPEARANCE AND ECONOMY OF MAINTENANCE

Anton Anderson, Chairman, Sub-Committee; F. L. Guy, J. C. Holden, C. B. Harveson, W. G. Brown, F. W. Hillman, A. A. Johnson.

The Committee understands the term "policing" as used in this subject to mean the caring for the right-of-way, including everything which goes to improve its appearance and to add to the safety and convenience of operating the railway, and the protecting of the company's property against fire or damage in other ways, against the intrusion of persons or of live stock, and against its being made a dumping ground for rubbish, etc.

General correspondence with members of the Association and the Roadway Committee indicates that it is an almost universal practice to have the section forces police the right-of-way and station grounds.

The Books of Rules of practically all carriers contain more or less instructions on policing, under track inspection, general instructions, and duties of section foreman. Apparently, all are agreed that there is a good return for the expense involved in one form or another, such as the advertising value, the good appearance of the property, reclaiming all scrap and usable material, preventing of fires, etc.

The uniformity, orderliness and neatness of the right-of-way in general tend to increase the efficiency of company forces.

Improving the appearance of the right-of-way involves numerous actions, which include the clearing away of all brush, stumps, unsightly trees, rocks, hummocks of earth, etc., the mowing of the right-of-way and the disposal of the grass and weeds cut down, the clearing away of rubbish which finds its way onto the railway's grounds, the collecting and disposal of coarse gravel or rocks which are culled out of ballast because of being too large.

The time to begin the cleaning up of the right-of-way is while the roadbed is being built. All grading operations should, so far as possible, be conducted in such manner that no places shall be left so uneven that they will interfere with the mowing of right-of-way by mowing machines, nor should depressions or holes be left in which water will stand. Maintenance of way, however, must take care of the thousands of miles of right-of-way of the railways, as it now exists, and the following pages endeavor to present some means of improving the appearance of the roadway and at the same time lower the costs of keeping it in a presentable condition, if possible.

The extent to which waylands are prepared so that mowing and cleaning can be done neatly and economically, varies from nothing to very extensive work.

After the right-of-way has been burned over in the autumn and before the vegetation grows again in the spring, it should be gone over and all

stumps, snags, stone, trees, etc., should be cleaned out and burned or disposed of. Rough places should be smoothed over. By digging around them, old poles can be cut down low enough to be leveled off. Old fence wire and other rubbish should be placed in washes, or ditches, which it is desirable to fill up. Borrow pits and low places where water stands should be drained or filled up, surplus material from cleaning or ditching, etc., should be used to fill holes and low spots or it should be leveled off so that a mowing machine will work over it without trouble. In some cases a tractor with a road grader can be used to good advantage in smoothing off the right-of-way.

The clearing up of the right-of-way should also include the collecting into piles of all loose rocks, and particularly the coarse refuse from the ballast, in such manner that when riprap or filling material is needed, the rock can be loaded conveniently with the aid of a derrick or locomotive crane, thus making the cost of riprap pay for the clearing.

After clearing up the right-of-way and leveling it so that it can be mowed by machine wherever possible, such right-of-way should be seeded to the best variety of hay grass which the locality will produce. After this has been done, farmers are usually glad to mow the right-of-way for the hay, thus eliminating all the cost of mowing to the company.

To prevent fires, some roads clean the outer edge of the right-of-way from two to five feet in width. If the adjoining fields are susceptible to the spread of fire the more general practice is to have fire guards made by plowing a few furrows parallel to the right-of-way and at such distance outside of it as will prevent fire starting outside of the guards, due to sparks from passing locomotives. The permission to plow such fire guards, and the cost of the work usually depends upon the Section Foreman's ability as a diplomat.

Most states have laws which require noxious weeds to be cut before seeding time or in certain months. The killing of troublesome weeds and grasses can be greatly aided by burning over the right-of-way after the mown material has had time to dry.

The cost of mowing varies from nothing to $100 or more per mile, depending on the standard of the railway and the roughness or uneveness of the right-of-way, and the kind of growth to be cut. On one railway in Missouri and Kansas, the actual cost of mowing right-of-way in 1927 averaged (with right-of-way 100 ft. wide) by hand mowing, $41 per mile, and where teams could be used, the average cost was $15.40 per mile. This shows that a saving of at least $25.60 per mile per annum can be made by smoothing up right-of-way so that it can be mowed by machine instead of mowing it by hand.

This represents 5½ per cent earnings upon $465 and by judicious handling of the necessary cleaning up, such as making use as riprap of the rock collected, or making use of earth removed, for filling material or for widening banks, the sum which can be spent for smoothing up right-of-way can be made to accomplish surprising improvements.

Where shrubs, trees and flowers are maintained, the maintenance work

is, of course, more expensive. Particular attention is paid by some carriers to having the right-of-way in residential and industrial districts cleaned up and planted to conform with the locality in which the right-of-way is located. They feel that a well-kept property is always attractive and in general the public will be favorably impressed by the attractive appearance thus produced.

The practice of every railway company should be some method whereby the section forces, as a matter of routine, are required to keep their sections in standard shape, or condition, including general appearance. In order to reduce the expense to a minimum, instructions should provide that the work be done as a matter of daily routine, with the various elements of the work done at the most seasonable periods of the year, or at such periods as best permit of work which can be done at any time being performed without interfering with other work which must be done at some specified time or fixed season.

To give a good appearance, the ballast section should be clean with the toe line of the ballast and the sod, or bank lines, straight, or parallel with the track. Grass and weeds should be kept down. Usable material should be kept piled in neat piles and scrap material should be promptly conveyed to the scrap bins, both to improve the appearance of the railway grounds and to prevent its being lost in the weeds or covered up by excavated material, or in the ballast, and thus lost. In cleaning up right-of-way, like in all other work, it is good practice to finish the work up to standard as the work progresses and not to leave it in a partially finished condition, expecting to come back and finish it at some other time.

Material taken from cuts, or from the right-of-way along embankments, for bank widening or for other purposes, should be so handled that both the place from where it is taken and the place where used will be finished in a workmanlike manner so as to leave the surface smooth and of good appearance.

The use of weed killing chemicals, applied with hand apparatus, around buildings may be done effectively. Care should be taken in its application so that ragged or irregular grass lines will not result from its use.

Fences should be maintained in straight lines or on uniform curves as required by the property lines. Wing fences, rail rests, stone trim or edging around signals and handcar setoffs, etc., can be improved in appearance at small expense by whitewashing. Such attention results in giving the whole right-of-way a uniform and good appearance.

Trash, refuse, ashes, brush, etc., should be piled in designated places as it accumulates and disposed of before it produces an unsightly condition. A neat and well kept right-of-way is a feature which catches the eye, and usually the attention, of those traveling over, or along the railway, and cannot help creating a favorable impression, which is a result always to be desired.

REPORT OF COMMITTEE IV—RAIL

Earl Stimson, *Chairman;*
E. E. Adams,
Lem Adams,
J. E. Armstrong,
W. J. Backes,
J. B. Baker,
A. F. Blaess,
F. L. C. Bond,
C. B. Bronson,
E. E. Chapman,
W. C. Cushing,
J. M. R. Fairbairn,
J. M. Farrin,
L. C. Fritch,
E. A. Hadley,
C. R. Harding,
Hunter McDonald, *Vice-Chairman;*
R. H. Howard,
L. J. F. Hughes,
John D. Isaacs,
C. W. Johns,
R. Montfort,
A. W. Newton,
W. H. Penfield,
G. A. Phillips,
G. J. Ray,
C. P. VanGundy,
F. M. Waring,
W. P. Wiltsee,
Louis Yager,
J. M. Young,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual.

(2) Continue the study of details of mill practice and manufacture as they affect rail quality (Appendix A).

(3) Continue the study of rail failures (Appendix B).

(4) Continue the study of transverse fissures (Appendix C).

(5) Continue the study of cause and prevention of rail battering, collaborating with Committee V—Track (Appendix D).

(6) Study the economic value of different sizes of rail.

(7) Study the reconditioning of battered or worn rail ends by electric welding process, with especial reference to the effect upon rail.

(8) Study the drilling and spacing of holes in rails of all weights, and sizes of bolts for use with each weight.

(1) Revision of Manual

The Committee proposes no material for Manual revision this year.

(2) Mill Practice

The Committee has continued its study of mill practice as affecting quality of steel rail and calls attention to Appendix A, which outlines improvements that have been made at the various steel mills.

The Committee has undertaken jointly with the rail manufacturers investigations which will be referred to later under Subject (4) Transverse Fissures.

(3) Rail Failures

The Committee presents rail failure statistics for the period ending October 31, 1926, as Appendix B.

Table 1—Average Failures Per 100 Track Miles

Year Rolled	*Years' Service* 1	2	3	4	5
1908	....	....	....	....	398.1
1909	....	....	....	224.1	277.8
1910	....	....	124.0	152.7	198.5
1911	....	77.0	104.4	133.3	176.3
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	....
1923	14.3	33.2	57.6	....	....
1924	14.0	33.4	....	....	....
1925	15.5	....	....	....	....

The five-year record of the 1921 rollings is materially better than any rolling since 1915 as was forecast in last year's report. The four-year record of the 1922 rollings indicates that the improvement in the failure rate will continue, but probably will not quite equal the low rate of the 1921 rollings.

The Committee again presents in the rail failure report a chart showing the rating of mills through the use of the traffic density factor, as well as the rating by our usual method.

(4) Transverse Fissures

Last year's report referred to the development of a device for the detection of transverse fissures in rail steel, which is being financed by this Committee with appropriations secured from the American Railway Association. The Committee now reports that following the highly satisfactory completion of laboratory tests of a simple stationary type of this device, a test car has been constructed designed to print, simultaneously, records of transverse fissures existing in both rails in track when the test car is hauled over the track at a speed of approximately 10 m.p.h.

This device will segregate such fissures as to size and automatically mark the defective rails by means of a paint spray applied to the outside of the webs of the rails.

Owing to the fact that the service test of this "Detector Car" will not take place until a few days after the date of this writing, the Committee is unable to make complete report at this time, but will later supplement its report on this subject.

Transverse fissure statistics have been extended to include all failures from such cause reported up to January 31, 1927, and are presented as Appendix C. The record now comprises a total of 27,346 transverse fissure rail failures. The 1926 rollings from all mills produced in the first year of service 72 per cent more fissure failures than did the 1925 rollings during their first year of service.

The Committee is in active co-operation with the Rail Manufacturers' Technical Committee in the attempt to determine the original cause of transverse fissures. A series of tests has been outlined in which test rails, which in their manufacture have been subjected to different cooling conditions, heat treatments, etc., will be examined by deep etching for shattering cracks. Microscopic examinations and thorough chemical and physical tests will also be made.

The Bethlehem Steel Company, co-operating with the Pennsylvania Railroad, and the Carnegie Steel Company, co-operating with the Baltimore and Ohio Railroad, will undertake to carry out these tests.

(5) Rail Batter

The Committee presents, as Appendix D, a progress report on this subject in collaboration with the Committee on Track.

(6) Economic Value of Different Sizes of Rail

The Committee reports progress on this subject.

(7) Reconditioning of Battered or Worn Rail Ends

The Committee has under way an investigation of the effect upon rail steel of reconditioning by acetylene and electric welding processes and reports progress at this time.

(8) Drilling and Spacing of Holes in Rails of All Weights

The Committee has given this subject careful study and reports progress.

Action Recommended

(1) No revisions of the Manual are recommended.
(2) That the report in (Appendix A) be received as information.
(3) That the report in (Appendix B) be received as information.
(4) That the report in (Appendix C) be received as information.
(5) That the report in (Appendix D) be received as information.

Recommendation for Future Work

1. Revision of Manual.
2. Continue the study of details of mill practice and manufacture as they affect rail quality, collaborating with the Rail Manufacturers' Technical Committee.
3. Continue the study of rail failures.
4. Continue the study of transverse fissures, collaborating with the Rail Manufacturers' Technical Committee.
5. Continue the study of cause and prevention of rail battering, collaborating with Committee V—Track.
6. Continue the study of the economic value of different sizes of rail.
7. Continue the study of reconditioning of battered or worn rail ends by electric welding process with especial reference to the effect upon the rail.
8. Continue the study of the drilling and spacing of holes in rails of all weights, and sizes of holts for use with each weight.

Respectfully submitted,

The Committee on Rail,
Earl Stimson, *Chairman.*

Appendix A

(2) DETAILS OF MILL PRACTICE AND MANUFACTURE AS THEY AFFECT RAIL QUALITY

C. B. Bronson, Chairman, Sub-Committee; J. E. Armstrong, F. L. C. Bond, E. E. Chapman, W. C. Cushing, C. R. Harding, G. J. Ray, C. P. VanGundy, F. M. Waring, J. B. Young, W. C. Barnes.

Your Committee presents as information the following notes on recent changes and improvements in mill practice.

Several important changes and improvements have occurred in rail manufacturing processes within the past year or more, which are in part directly traced to the changing requirements of the railways. Specific details are not entirely available for the different steel companies manufacturing rails, but the general trend is given as indicative of the improvements and changes which have developed.

Rail production records show a marked increase in the demand for heavier rails, particularly within the last five years. The percentage of rails of 100-lb. per yard or heavier to the total rail production increased from 28 in 1920 to 61 per cent in 1926. Increased weight combined with the almost universal adoption of the 39-ft. standard length has affected rail handling methods in the finishing mill and back as far as the open-hearth department.

In the open-hearth departments, changes have been made in furnace construction as to their width, length, shape of roof, back wall, as well as changes in design of the ports at either end, increasing the efficiency of combustion, mixing and flame action to effect more thorough refinement in the bath. Tar and oil have been used on some furnaces to increase the intensity and sharpness of the flame action, and decrease the sulphur carried into the bath.

The work at the pouring platform at some mills has been improved by coating the interior of the molds with both graphite and tar, which prevent the splattering particles of molten metal from adhering to the sides of the mold, and creates much smoother ingot surfaces for easier rolling conditions.

The permissible increase in percentage of silicon which was introduced into the A.R.E.A. and other rail specifications has reduced or eliminated the necessity of "killing" the steel in the molds with aluminum, and its use has now been discontinued at several plants.

Stopper rods and nozzles for ladles have received considerable attention, and improvements have been made in the type and materials used to reduce the liability of spattering, or leaking and running stoppers when filling the ingot molds.

Some mills have introduced changes in the shape and size of ingot molds, particularly wall thickness and cross-section at the bottom compared to the top, and have increased the radii at the corners to prevent cracking of the molds and shortening their life, and have thus reduced the possibility of weakness in the corners of the cast ingots.

"Hot top" molds were also used on sizable experimental tonnages by three different roads independently. The purpose of these tests was to determine what effect this type of mold has on the various processes involved in rail manufacture, and to determine the relative quality of the material compared to that made in standard ingot molds. The rails are now in service and at some later date, interesting test data may be available.

The practice of duplexing steel by the rapid conversion of Bessemer into open-hearth has been abandoned by most of the rail mills, and the open-hearth furnaces in these installations have now been converted for standard open-hearth heats.

Changes have been made in both the type and composition of the rolls used at some of the rail mills for the purpose of increasing their life and usefulness, reduce roll failures, and by reducing the wear on the roll obtain rail sections which are closer to template.

The desirable practice of wash heating the blooms after the ingot has been reduced to bloom size and before rolling into rails has been extended, and at present one mill is engaged in rebuilding its plant and incorporating reheating furnaces for this purpose.

A decided improvement has taken place in the hot sawing of rails at several rail mills. Experiments were made with various types and thicknesses of saws so that the end faces of the cross-sections cut through would not contain objectionable and deep ridges, be maintained practically square, and reduce the saw burr. Automatic and adjustable curving or cambering rolls have been installed and are proving of great value in eliminating the drag and blurring of the burr from the hot saw cut. The result is that a much smoother and more even finish is secured on the rail ends.

The practice of spacing of rails on the hotbeds to promote uniform cooling is now being followed by several of the rail mills, and has resulted in a noticeably smoother rail at the straightening presses and a reduction in the amount of gagging required to straighten rails. The equipment for handling rails on the hotbed is rather elaborate at some mills, while the rails are being spaced largely by hand at other plants.

The arduous work of handling long and heavy rails in the straightening presses has caused some mills to devise and install mechanical devices for rotating rails into position under the presses. Preliminary trials have also been made with roller straighteners to determine the advantages and possibilities of the use of this practice which is general in the European rail mills.

The classification of rails as to quality, fitness, chemistry, as well as lengths, as outlined in the A.R.E.A. and other specifications, has necessitated remodeling of the finishing mills at many rail plants, and the handling facilities. The change from the 33 to 39-ft. standard length required the expenditure of several million dollars in the aggregate for all of the rail mills.

Economic conditions have recently required one rail mill in the Eastern district to rebuild and enlarge its facilities at the cost of several million dollars, and in particular to meet the demands for heavier and longer rails.

As to the use of different grades of steel, there has been a considerable increase in the demand for intermediate or medium manganese, which is a steel of promising superiority over the standard open-hearth composition.

Experimental lots of heat-treated rails have recently been installed on five different railroads on sharp curves in heavy traffic territory. Cumulative data are being secured of the relation of cost, physical characteristics and wear compared to standard untreated rails. There has been more activity in experiments on heat-treated rails during the past year than for a great many years, and the experiments are being observed in a number of different places.

Appendix B

(3) RAIL FAILURE STATISTICS FOR 1926

By W. C. Barnes, Engineer of Tests, Rail Committee

The rail failure statistics for the year ending October 31, 1926, appearing in this report, have been compiled in accordance with the standard method of basing the failure rate on mile years of service in track.

The rollings for 1921 and succeeding years are embodied in these statistics, the tonnages and track miles reported being as follows:

Year Rolled	*Tons*	*Track Miles*
1921.....	1,192,112	7,686.27
1922.....	1,118,711	7,116.14
1923.....	1,553,362	9,737.02
1924.....	1,488,415	9,371.49
1925.....	1,752,426	10,838.62

Table 1 shows the average results of all of the rail from all mills reported on, together with the results taken from previous reports, including both Bessemer and Open-Hearth rails. The 1921 rollings, whose period of observation is now concluded, show a lower failure rate than any rolling since 1915, as was forecast in last year's report. The four-year record of the 1922 rollings indicates that the improvement in the failure rate will continue, but probably will not quite equal the low rate of the 1921 rollings.

Fig. 1 shows diagrammatically the general average results.

Table 2 presents a summary from 14 years' reports showing track miles and total failures in addition to the failures per 100 track miles shown in Table 1. The average results of the rails from each of the mills for rollings since 1908 are given in Table 3 and these results are shown diagrammatically in Fig. 2.

Table 4 and Fig. 5 present the performances of rails rolled at each of the mills in recent years. In Table 4 the failures per 10 track miles per year of service are shown and the weighted average is shown for the rollings from 1921 to 1925, inclusive, for each mill. These averages, which take into account the mileages represented in each of the five years' rollings, are presented diagrammatically in Fig. 3. Inland again shows the lowest

failure rate, but this is somewhat offset by the fact that no 1921 rail is represented therein. Illinois again shows the lowest rate on a comparable basis with a figure of 8.32. Pennsylvania is next in line with 11.17, followed by Colorado with 12.31, and Carnegie with 12.67. This somewhat changes the ranking of last year in which Carnegie held second place after Illinois. Due to absence of reports on Maryland rollings from 1922 to 1924 inclusive, and on Dominion rollings for 1921 to 1924 inclusive these two mills do not appear in Fig. 3, 4 and 5, nor in Table 4.

Fig. 4 rates the relative performance of the mills from the same data as used for Fig. 3, except that a traffic density factor has been introduced into the final computations. A factor for each reporting road, based on its revenue freight ton miles per mile of road, was applied to the rail tonnages on that road from any given mill and the resulting weighted average traffic density factor, for all rail on all roads from that mill, was applied to the failure rate of that mill's output as given in Fig. 3. In like manner, weighted traffic density factors were obtained and applied for rail from each mill. No claim is made for the entire accuracy for this system of rating, but it does give more consideration to the work which the failed rails from the respective mills are called upon to perform, than does the system of rating on which Fig. 3 is based. Fig. 4 is similar to Fig. 4 of last year's report and is presented as information.

Table 5 shows the average weight of rails, from the various mills and from all mills. The average reported for the year 1925 stands at 102.8 lb. per yard.

Table 1—Average Failures per 100 Track Miles

Year Rolled	YEARS SERVICE				
	1	2	3	4	5
1908	-	-	-	-	398.1
1909	-	-	-	224.1	277.8
1910	-	-	124.0	152.7	198.5
1911	-	77.0	104.4	133.3	176.3
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	
1923	14.3	33.2	57.6		
1924	14.0	33.4			
1925	15.5				

Table 2—Summary from Fourteen Years' Reports Showing Track Miles Originally Laid. Total Failures and Failures per 100 Average Track Miles in Service

Service	Five Years			Four Years			Three Years			Two Years			One Year		
	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls
From 1913 Report															
Year Rolled Totals-	3201.35	1908 12746	398.1	6340.54	1909 14208	224.1	9860.18	1910 12227	124.0	6536.05	1911 5030	77.0	7105.74	1912 2050	28.9
From 1914 Report															
Year Rolled Totals-	6697.39	1909 18605	277.8	10024.85	1910 15309	152.7	6096.48	1911 6354	104.4	7610.60	1912 2431	32.1	8775.44	1913 1095	12.5
From 1915 Report															
Year Rolled Totals-	11587.43	1910 22981	198.5	7980.75	1911 10635	133.3	10374.18	1912 5119	49.3	10668.59	1913 2756	25.8	7061.24	1914 584	8.2
From 1916 Report															
Year Rolled Totals-	7969.41	1911 14052	176.3	10260.93	1912 8100	78.9	11235.41	1913 5076	44.8	7505.24	1914 1483	19.8	7381.29	1915 656	8.9
From 1917 Report															
Year Rolled Totals-	10778.68	1912 11546	107.1	12526.60	1913 8706	69.5	7819.79	1914 2576	32.9	7344.65	1915 1395	19.0	8532.53	1916 1004	11.8
From 1918 Report															
Year Rolled Totals-	11883.57	1913 10924	91.9	7752.27	1914 3948	50.9	7072.23	1915 2414	34.2	8347.44	1916 2439	29.2	7384.26	1917 1596	21.6

From 1919 Report															
Year Rolled Totals-	7917.26	1914 5855	74.0	7280.51	1915 3862	53.0	8407.55	1916 4013	47.7	7615.46	1917 2962	38.9	6354.44	1918 568	8.9
From 1920 Report															
Year Rolled Totals	7346.50	1915 6057	82.4	8062.10	1916 5691	70.6	7334.40	1917 4844	66.0	6658.80	1918 1837	27.6	6676.60	1919 986	14.8
From 1921 Report															
Year Rolled Totals	7820.14	1916 8248	105.4	7025.25	1917 7765	110.5	6313.98	1918 3414	54.0	6271.82	1919 2477	39.4	7341.71	1920 1044	14.2
From 1922 Report															
Year Rolled Totals	6945.43	1917 9532	137.0	6117.93	1918 5681	92.8	6402.43	1919 4719	73.7	7550.62	1920 2448	32.4	7421.29	1921 806	10.9
From 1923 Report															
Year Rolled Totals	5756.11	1918 7221	125.4	6388.57	1919 6697	104.8	7200.83	1920 4545	63.1	7328.52	1921 2568	34.9	7116.16	1922 1135	15.9
From 1924 Report															
Year Rolled Totals	5913.86	1919 6845	115.7	7271.00	1920 6146	84.5	6857.55	1921 3905	56.9	6974.38	1922 2429	34.8	9501.95	1923 1363	14.3
From 1925 Report															
Year Rolled Totals	6576.48	1920 7759	119.6	6640.46	1921 4950	70.9	6765.99	1922 3514	55.2	8692.16	1923 2791	33.2	7804.78	1924 1098	14.0
From 1926 Report															
Year Rolled Totals	7686.27	1921 7376	98.9	7116.14	1922 5594	80.4	9737.02	1923 5454	57.6	9271.49	1924 3130	33.4	10828.62	1925 1701	15.5

Table 3—Failures for Various Ages of Rail per 100 Track Miles

Year Rld	Years Service 1	2	3	4	5	Years Service 1	2	3	4	5
	Algoma					Bethlehem				
1908					482.9					503.7
1909				203.7					466.1	
1910			431.0		13.8			174.0	245.0	330.9
1911		219.7					113.3	195.3	251.7	329.8
1912	124.0					11.9	32.0	52.1	83.2	106.8
1913						13.4	26.9	52.6	77.3	99.5
1914	19.0	43.2	67.1	67.9	321.4	3.8	6.9	16.0	21.6	33.0
1915	7.1	11.8	22.9	39.1	84.0	17.1	24.5	41.0	65.0	92.4
1916	22.7	42.1	63.4	96.8	139.9	17.7	42.4	75.2	110.9	152.0
1917	2.0	2.0	9.1	29.7	62.9	39.0	59.2	94.8	127.7	157.5
1918						19.6	57.7	78.4	91.5	133.7
1919	7.3	26.6	55.8	82.9	36.7	31.2	72.3	105.0	160.7	213.9
1920	2.6	16.5	41.0	278.5	472.0	10.5	57.5	56.5	84.5	95.5
1921	4.6	13.4	27.0	42.4	65.2	12.9	63.4	88.4	114.3	143.5
1922	17.4	51.7	83.0	125.5		55.6	77.3	130.6	177.4	
1923	30.3	74.5	115.8			7.4	18.8	47.0		
1924	18.5	48.9				23.2	40.3			
1925	2.3					22.9				
	Cambria					Carnegie				
1908										
1909				244.8	326.6				104.1	137.1
1910			98.5	136.4	201.0			98.9	112.9	101.1
1911		73.7	126.1	227.7	257.2		71.5	108.9	123.1	165.6
1912	17.1	41.8	74.3	108.9	140.9	12.3	30.9	55.3	78.4	98.8
1913	26.7	49.5	78.3	106.2	120.1	8.9	19.4	33.8	62.9	80.0
1914	15.8	37.7	61.9	64.3	137.7	5.5	11.9	16.6	25.4	48.8
1915	6.3	19.5	34.1	58.7	111.5	1.8	8.6	16.9	29.2	43.7
1916	7.3	25.9	33.7	73.7	157.6	4.9	13.2	26.8	45.6	69.7
1917	23.9	38.9	112.9	311.6	394.2	6.1	19.5	39.3	73.3	92.2
1918	32.9	95.5	248.0	369.7	507.4	6.2	41.6	50.2	73.7	135.5
1919	33.3	75.2	82.6	103.2	152.7	8.5	35.9	36.5	46.5	60.5
1920	37.6	44.2	96.8	158.5	223.1	7.0	15.1	34.4	59.4	87.8
1921	13.8	43.2	101.2	158.8	237.4	3.3	8.6	23.6	37.5	52.8
1922	16.1	43.9	62.0	72.0		8.4	20.4	38.0	48.7	
1923	12.6	36.9	63.3			4.1	13.9	26.0		
1924	47.5					10.6	33.8			
1925						17.1				
	Colorado					Dominion				
1908					45.5					
1909				22.4	34.2					
1910			19.6	23.4	60.9					
1911		15.8	31.0	52.6	84.3					
1912	18.3	40.9	55.6	91.3	117.6					
1913	3.9	11.0	26.0	46.6	82.1					
1914	3.7	7.6	14.1	27.3	42.0					
1915	4.6	7.7	15.1	34.4	80.3					
1916	5.8	15.7	34.5	53.6	78.1					
1917	5.4	12.5	38.7	51.5	42.6					
1918	6.5	13.1	39.7	109.0	184.8		60.0	149.0	420.9	482.7
1919	5.0	18.5	32.9	65.2	90.2	5.7	102.3	185.9	298.3	396.0
1920	9.3	27.6	75.0	96.5	138.3					
1921	9.2	31.7	50.6	72.7	97.8	60.9				
1922	12.0	27.1	58.9	111.6						
1923	7.0	29.3	54.3							
1924	4.3	9.6								
1925	3.8					2.6				
	Illinois					Inland				
1908										
1909				151.9	219.7					
1910			88.4	136.8	206.2					
1911		67.5	94.0	107.7	178.6					
1912	7.4	23.2	39.2	64.6	100.0					
1913	10.0	21.9	44.0	62.1	91.5					
1914	11.6	30.0	47.3	83.6	98.3					
1915	10.7	21.9	40.9	56.1	78.8					
1916	11.1	26.0	43.9	70.7	97.3					
1917	9.1	19.9	46.3	75.5	107.7					
1918	2.5	10.8	18.5	45.4	50.3					
1919	11.5	26.8	43.7	77.1	107.1					
1920	5.4	13.3	36.9	55.6	84.2					
1921	4.2	16.2	27.0	41.7	58.9					
1922	5.0	11.2	20.6	29.4			19.0	35.7	53.1	
1923	6.6	17.2	32.5			7.6	12.8	20.4		
1924	5.4	10.9				2.6	6.7			
1925	5.6					5.6				

Table 3—Failures for Various Ages of Rail per 100 Track Miles —(Continued)

Year Rld	Years Service 1	2	3	4	5	Years Service 1	2	3	4	5
	Lackawanna					Maryland				
1908					143.5					
1909				100.1	117.8					
1910			42.7	90.3	148.9			69.6	104.8	163.7
1911		29.5	57.1	108.6	162.5		32.9	49.5	58.5	67.4
1912	4.8	20.1	39.6	67.1	88.6	11.3	5.8	18.1	8.6	110.8
1913	17.2	31.4	51.9	74.0	115.3	28.6	74.1	88.4	117.0	159.7
1914	1.8	10.0	24.5	49.3	78.7	13.3	25.2	31.4	36.2	62.9
1915	10.5	23.8	38.1	57.3	73.1	24.5	60.2	99.6	138.1	231.4
1916	8.9	25.5	40.1	58.0	76.9	30.7	61.8	92.3	96.6	180.3
1917	16.8	31.6	46.6	78.3	104.5	160.5	214.2	360.5	425.5	445.5
1918	7.4	23.7	43.8	65.5	93.2	23.7	59.2	113.6	139.1	210.2
1919	22.8	51.9	77.4	86.7	153.0	34.2	52.8	60.8	90.8	106.9
1920	14.5	27.1	50.6	74.1	99.0	0.0	2.3	11.9	11.9	
1921	3.8	19.0	41.3	62.4	83.2	0.0	7.2	25.3		
1922	4.0	13.6	22.6	36.6						
1923	18.6	35.9	57.6							
1924	18.5	29.3					1.5			
1925	16.7					11.2				
	Pennsylvania					Tennessee				
1908					72.9					86.5
1909				86.3	101.4				11.1	83.7
1910			81.4	110.9	123.8			32.4	47.8	55.2
1911		34.6	79.6	119.0	145.2		14.9	25.1	40.8	61.7
1912	5.3	15.6	27.5	46.8	60.4	7.3	32.9	43.9	64.5	83.2
1913	9.6	21.0	34.7	47.2	71.2	5.7	16.5	24.5	41.6	57.3
1914	8.2	21.1	29.4	38.0	49.7	7.5	16.6	29.0	44.2	60.8
1915	6.3	18.1	27.9	48.4	59.6	6.0	16.0	30.5	48.0	70.9
1916	35.6	46.1	94.2	136.1	171.7	15.6	37.1	61.1	82.2	123.4
1917						17.3	35.7	58.2	102.5	109.5
1918	2.4	9.2	20.7	50.6	76.0	16.4	34.6	79.9	143.1	145.3
1919	46.9	79.6	139.8	175.1	233.8	14.1	34.2	100.7	132.3	79.7
1920	56.3	38.5	73.2	96.7	139.5	39.9	83.1	149.3	189.8	232.4
1921	4.9	12.2	25.9	41.6	66.1	37.5	84.9	149.7	184.7	231.6
1922	10.3	18.7	20.1	29.7		42.7	106.7	172.0	204.7	
1923	10.0	16.7	31.2			42.4	100.4	136.2		
1924	16.6	38.9				32.6	82.4			
1925	7.8					35.5				

All Mills

Year Rld	Years Service 1	2	3	4	5
1908					370.5
1909				163.6	198.5
1910			81.3	107.1	154.0
1911		53.0	83.5	111.2	161.9
1912	26.3	28.9	46.0	74.2	102.7
1913	11.5	24.8	43.3	68.5	90.3
1914	8.0	18.9	30.8	47.4	74.0
1915	8.8	19.0	33.8	53.0	82.4
1916	11.7	27.9	47.7	70.6	105.4
1917	21.8	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.8	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	
1923	14.3	33.2	57.6		
1924	14.0	33.4			
1925	15.5				

Table 4—Recapitulation—Totals and Averages Grouped by Mills. Track Miles—Represents Quantity Originally Laid. Failures to Date—Computed by Mile Years of Rail in Service

Year	Track Miles	Total	Failures to Date Per 100 Track Miles		Track Miles	Total	Failures to Date Per 100 Track Miles	
			To Date	Per Year			To Date	Per Year
	Algoma				Bethlehem			
1921	605.35	394	65.18	13.03	447.22	632	142.52	28.70
1922	365.12	458	125.51	31.37	186.56	369	177.42	44.35
1923	420.39	497	115.84	38.61	978.48	427	47.04	15.68
1924	500.84	245	48.91	24.45	593.73	231	40.34	20.17
1925	479.15	11	2.29	2.29	748.64	170	22.87	22.87
Totals	2380.85	1605		21.73	2954.63	1829		21.88
	Cambria				Carnegie			
1921	184.34	426	230.42	47.46	984.32	506	52.81	10.56
1922	300.23	205	71.99	17.99	782.80	377	48.73	12.18
1923	261.05	135	63.33	21.11	1191.01	296	25.99	8.66
1924					932.18	309	33.81	16.90
1925					1200.58	197	17.12	17.12
Totals	745.62	766		24.33	5091.89	1685		12.67
	Colorado				Illinois			
1921	689.54	634	97.75	19.55	2667.49	1554	58.87	11.77
1922	497.82	554	111.55	27.88	1829.53	533	29.37	7.34
1923	482.84	262	54.32	18.10	2521.81	813	32.50	10.83
1924	893.24	85	9.56	4.78	2270.55	244	10.86	5.43
1925	938.63	36	3.83	3.83	2265.75	125	5.58	5.58
Totals	3502.07	1571		12.31	11555.13	3269		8.32
	Inland				Lackawanna			
1921					515.61	405	83.16	16.63
1922	288.16	146	52.13	13.28	961.63	333	36.58	9.14
1923	561.32	112	20.36	6.78	775.84	432	57.55	19.18
1924	641.48	48	6.74	3.37	587.49	170	29.30	14.65
1925	711.89	38	5.56	5.56	689.98	110	16.69	16.69
Totals	2202.86	344		6.16	3530.55	1450		14.25
	Pennsylvania				Tennessee			
1921	414.70	258	66.13	13.22	1177.70	2567	231.56	46.31
1922	664.64	191	29.67	7.41	1239.65	2428	204.65	51.16
1923	878.20	271	31.16	10.38	1656.07	2209	136.21	45.40
1924	825.90	318	38.86	19.43	1785.96	1475	82.40	41.20
1925	1071.65	82	7.76	7.76	2221.78	886	35.46	35.46
Totals	3855.09	1120		11.17	8081.16	9565		43.06

All Mills

Year	Track Miles	Total	Failures to Date Per 100 Track Miles	
			To Date	Per Year
1921	7686.27	7576	98.93	19.78
1922	7116.14	5594	80.40	20.10
1923	9737.02	5454	57.60	19.20
1924	9032.37	3125	34.64	17.32
1925	10228.05	1655	15.86	15.86
Totals	43899.85	23204		15.58

Table 5—Average Weights of Rails Compiled from Tonnages Used in This Report

Mill	1921	1922	1923	1924	1925
Algoma	101.6	102.1	100.8	100.5	100.9
Bethlehem	103.6	96.8	100.3	99.0	100.8
Cambria	125.5	117.3	111.8		
Carnegie	110.2	112.2	110.8	114.7	110.8
Colorado	89.8	89.9	91.5	90.6	102.7
Dominion					101.4
Illinois	95.8	96.7	97.9	98.5	101.3
Inland		98.3	98.4	96.7	104.3
Lackawanna	97.3	98.6	98.9	98.9	98.4
Maryland				99.9	91.3
Pennsylvania	113.5	112.9	118.5	124.4	123.0
Tennessee	88.2	91.4	95.5	94.6	94.5
Average	98.4	100.0	101.5	101.0	102.8

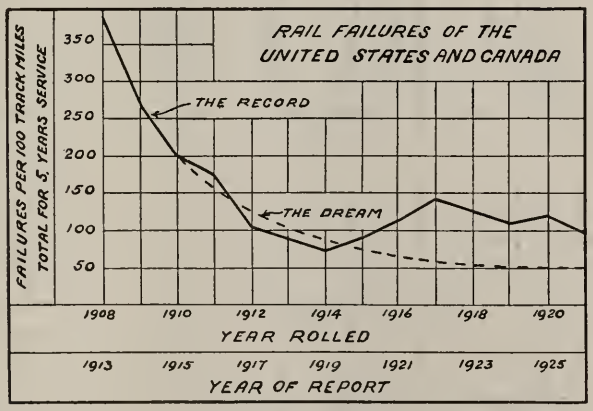

Fig. 1

Failures per 100 Track Miles—Total for Five-Year Period

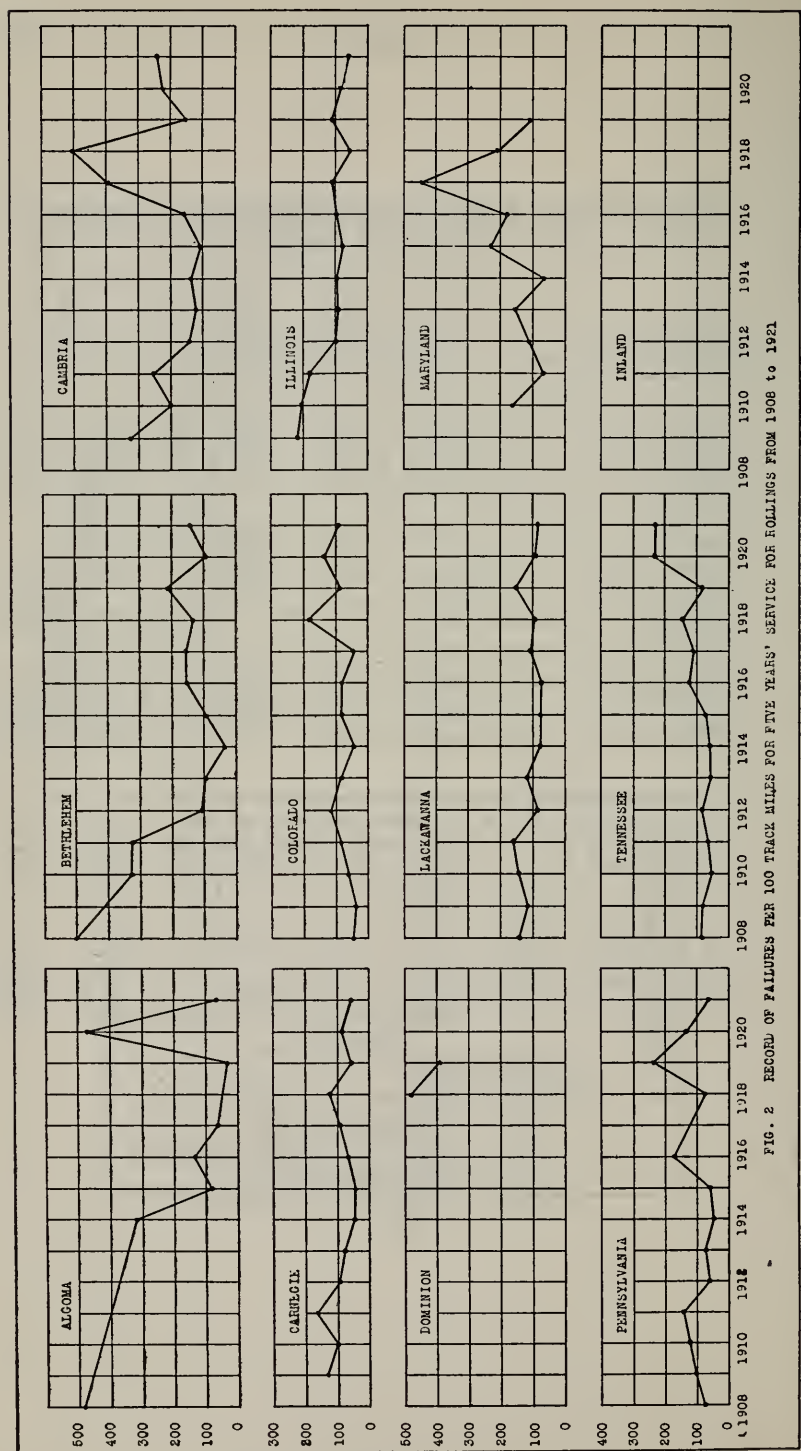

FIG. 2 RECORD OF FAILURES PER 100 TRACK MILES FOR FIVE YEARS' SERVICE FOR ROLLINGS FROM 1908 to 1921

Diagrams Showing Mill Ratings for Five-Year Period Compiled by Usual Method

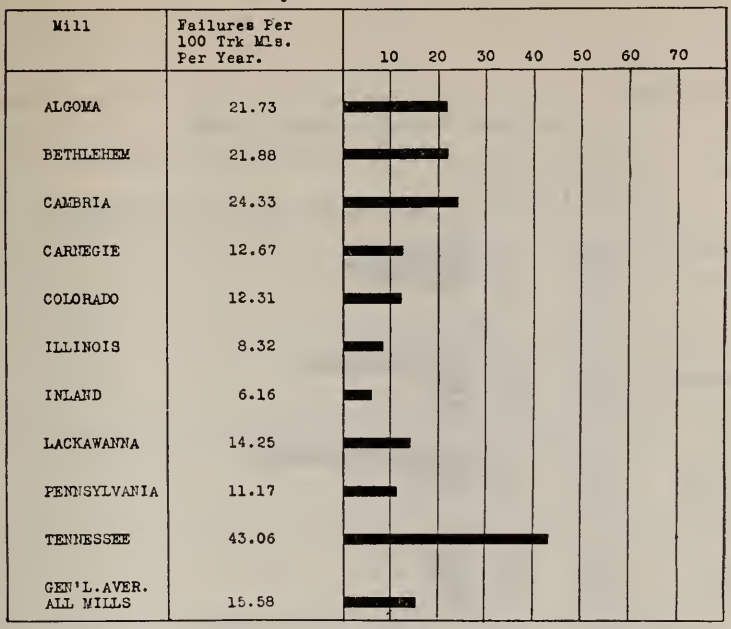

Fig. 3—Average Failures Classified by Mills for the Rollings from 1921 to 1925, Inclusive

Diagram Showing Mill Ratings for Five-Year Period as Altered by Use of Traffic Density Factor

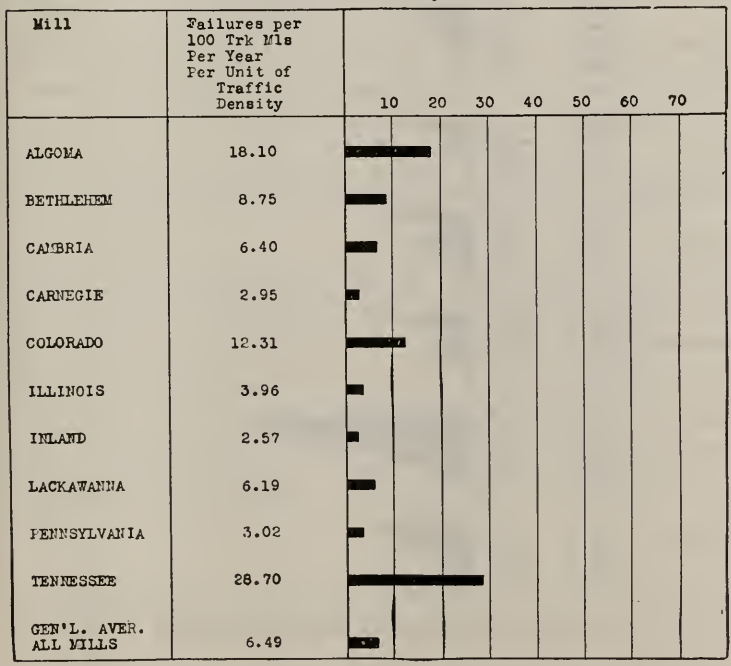

Fig. 4—This Diagram is presented for information only and shows ratios changed from those presented in Fig. 3.

Diagram Showing Failures per 100 Track Miles by Mills and Years for Period Ending October 31, 1927

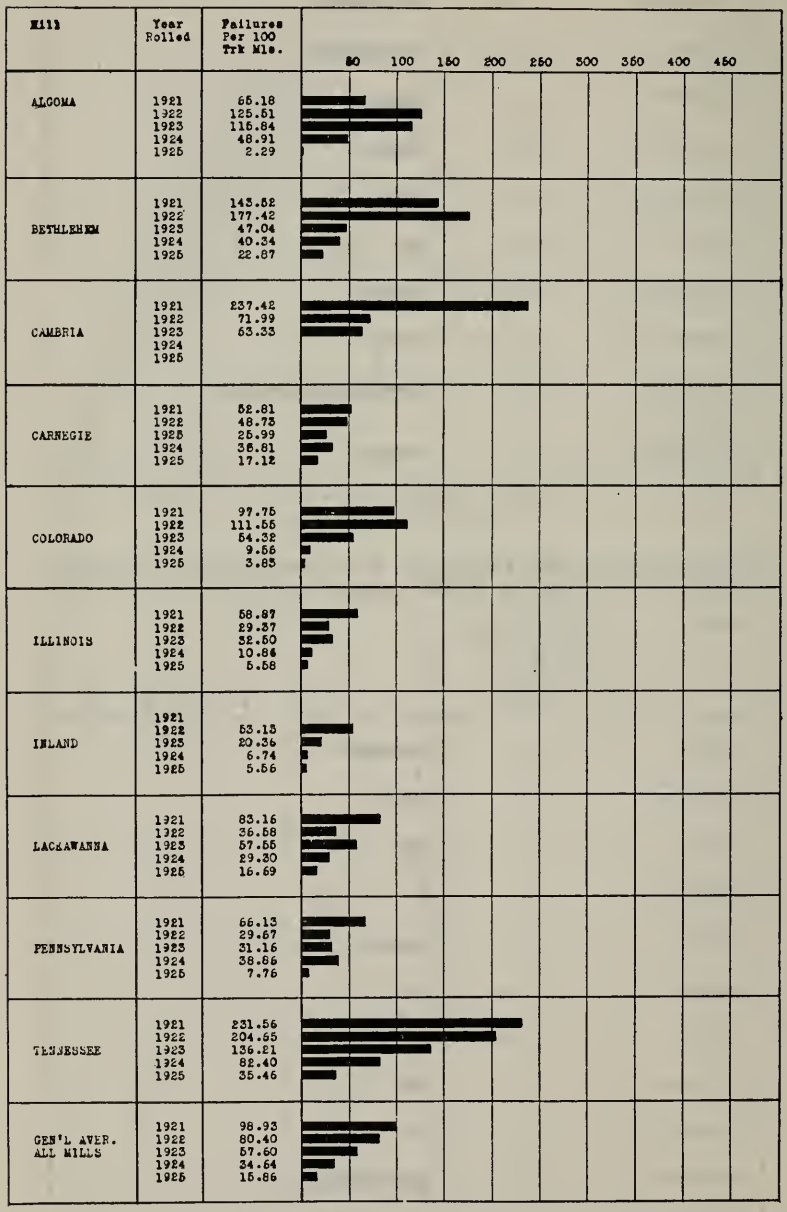

FIG. 5—Accumulated Failures for Rollings from 1921 to 1925

Appendix C

(4) TRANSVERSE FISSURE STATISTICS

By W. C. Barnes, Engineer of Tests, Rail Committee.

These statistics constitute a cumulative record of 27,346 simple transverse fissure failures that have been reported up to and including January 31, 1927.

Table 1 corresponds with Table 1 of last year's report and shows the number of simple transverse fissure failures reported by each of 49 reporting roads and the years in which such failures occurred. The Northern Pacific fissure failures for 1924 and 1925, which were received too late for inclusion in last year's report, have been added.

The total reported up to January 31, 1926, inclusive, was 22,750 and that up to January 31, 1927, 27,346, or an addition during the year 1926 of 4,596 fissure failures. This exceeds the total for the year 1925 by 460, of which 142 is due to roads not previously reporting, leaving a net increase over the year 1925 of 318 reported from previously reporting roads.

Table No. 2 corresponds with Table No. 2 of last year's report and classifies all the fissure failures accumulated from year rolled to January 31, 1927, for each year's rollings from each mill unweighted by tonnage output of mills and by amounts of traffic carried.

This table is most useful in comparing the failures in the various rollings from any one mill.

The rollings of 1910 from all mills continue to show the maximum number of fissure failures (2,912), which is due to the exceptionally bad record of the 1910 rolling from Illinois.

The 1913 rollings from all mills are a close second with 2,821 failures, influenced largely by Illinois and Maryland rollings.

The greatest number (502) of failures for all mills in 1926 occurred in the 1917 rollings, for which the excessive failures of Illinois 1917 rail are responsible.

The 1926 rollings from all mills produced, in the year 1926, 72 per cent more fissure failures than did the 1925 rollings in the year 1925, that is, there was an increase from 29 failures in 1925 rollings, to 50 in the 1926 rollings. This increase is due to the numbers of failures in the first year of service in rail rolled in 1926 at Carnegie, Illinois, Lackawanna and Tennessee mills.

Table No. 3 corresponds with Table No. 3 of last year's report and gives for each mill the rate of total transverse fissure failures on 31 selected roads accumulated to January 31, 1927, per 10,000 tons of rail reported on, by years rolled.

To reduce the confusing factors, in the preparation of this table, all fissure failures reported to date from the following roads were eliminated, viz.,

(1) Those for which rail tonnages are not available.
(2) Those which did not report prior to the year 1924.
(3) Those which have discontinued reporting.

This comparison includes a total of 22,225 fissure failures.

The perfect record for Maryland 1921 to 1923 inclusive rollings, is due to absence of tonnages of such rollings on those roads which are included in Table No. 3.

Table No. 4 classifies the accumulated transverse fissure failures by rail letter and by weight of section, by mills.

It will be noted that for all mills the majority of the fissure failures occurred in the A rails and that this holds in the case of individual mills such as Colorado, Illinois, Lackawanna, Pennsylvania and Tennessee, but that other mills consistently show the failures to predominate in the B, C or D rails.

For classification of fissure failures by carbon content, the reader is referred to Table No. 3 of Rail Report No. 92.

Roads making no report account incomplete records, etc.:

Alabama & Vicksburg
Ann Arbor
B. & O. C. T.
Central Vermont Ry.
Central R. R. of New Jersey
Chicago & Alton
Chicago Great Western
C. I. & L.
Colorado & Southern
Delaware & Hudson
Denver & Rio Grande
Duluth & Iron Range
Florida East Coast Ry.
Grand Trunk Railway System
Great Northern Ry.
Kansas City Southern
Lake Erie & Western
Maine Central R. R. & Portland Terminal
M. St. P. & S. S. M.
Minneapolis & St. Louis
Montour Ry.
Morgan's La. & Texas
M. M. & S. E.
New York, Ontario & Western
Pere Marquette
P. & L. E.
Temiskaming & Northern Ontario
Western Pacific
Wheeling & Lake Erie

Roads which have discontinued reporting:

C. B. & Q.
Missouri Pacific
N. Y. C. & St. L.

Table 1—Simple Transverse Fissure Failures by Railroads and by Year Failed
(Report Year Ends with January 31st of following Calendar Year.)

Railroad	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	Total	1926	Grand Total
A.T.& S.F.			1		1	6	19	13	25	177	220	134	126	81	79	882	71	953
A.C.L.																	11	11
Ban. & Aroos.																	11	11
B.C.& A.														0	0	0	0	0
Boston & Albany						2	1		1	17	23	30	25	15	10	9	133	3	136
Boston & Maine														35	69	72	176	78	254
B.& O.													212	297	369	878	253	1131
B.R.& P.												9	11	9	16	45	15	60
Can. Nat.																	13	13
Can. Pac.									4		8	16	59	86	158	331	277	608
Cen. of Ga.						3	51	52	52	23	41	31	29	24	40	346	20	366
C.& E.I.																	4	4
C.& O.											6	26	46	49	81	208	181	389
C.& N.W.																	85	85
C.B.& Q.									1	7	34	101	87	--	--	230	--	230
C.M.& St.P.								2		6	5	14	11	11	13	62	5	67
C.R.I.& P.					1	2	6	1	2	11	25	37	75	73	114	347	98	445
C.C.C.& St.L.												2	1	1	47	51	21	72
D.L.& W.		17	20	20	32	76	112	197	193	240	169	91	80	73	113	1433	128	1561
El Paso & S.W.												8	6	(See	So. Pac)	14		14
Erie												15	43	89	100	247	118	365
Hocking Valley												13	53	82	38	186	2	188
Illinois Central	1	1				2	3	4	35	121	190	372	556	419	501	2205	614	2819
Ind. Harbor												1	3	3	0	7	0	7
Lehigh & Hudson											1		4	4	16	25	33	58
L.& N.E.													32	0	0	32	0	32
Lehigh Valley												57	89	113	92	351	75	426
Long Island											2	8	7	11	2	30	3	33
L.A.& S.L.														1	7	8	12	20
L.& N.					(Prior	to 1919	--	174)	9	17	33	43	77	90	75	818	141	959
Mich. Cent.													2	5	11	18	13	31
M.K.& T											2	11	13	17	29	72	26	98
Mo. Pac.												2	8	--	--	10	--	10
Mobile & Ohio																	18	18
N.C.& St.L.				2	3	1	4			1	2	2	8	5	7	35	3	38
N.Y.C. (East)			4	43	76	124	101	67	84	88	93	136	107	126	165	1214	223	1437
N.Y.C. (West)										1	18	37	16	31	62	165	49	214
N.Y.C.& St.L.													2	--	--	2	--	2
N.Y.N.H.& H.												12	28	26	57	123	63	186
Nor. & Western												3	17	45	29	94	18	112
Nor. Pacific												42	39	120	161	362	152	514
Penna.				65	370	532	550	727	1114	1129	104	904	649	501	785	8430	868	9298
Reading												52	112	107	91	362	36	398
R.F.& P.																	0	0
Rutland														--	3	3	2	5
So. Pac.		15	4	6	11	15	4	2	9	6	130	118	143	175	243	881	335	1216
So. Ry.													24	6	13	43	51	94
Union Pacific											36	262	557	498	473	1826	356	2182
Western Md.															65	65	111	176
All roads	1	33	29	136	496	762	850	1540	1545	1850	249	2584	3382	3257	4136	22750	4596	27346

Table 2—Accumulated Simple Transverse Fissure Failures. Reported to January 31, 1927, by Years Rolled and by Mills

	Unknown			Algoma			Bethlehem			Cambria			Carnegie			Colorado			Dominion			German		
Year	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total
Unk.	22	5	27	8		8	12	3	15	11	5	16	13	4	17	16		16	2		2			
1889																								
1890																								
1891													1		1									
1892										2		2												
1893										1		1												
1894										6		6												
1895										5		5	1		1									
1896																								
1897										10		10	5		5									
1898										15		15	3	1	4									
1899										14		14	7		7									
1900										15		15	7		7									
1901										25		25	15	1	16									
1902							2		2	61		61	32		32	1		1				2		2
1903										57		57	59	2	61									
1904										21	1	22	38		38	1		1						
1905					2	2				23	3	26	31	1	32							2		2
1906							1	1	2	53	11	64	37	4	41				3		3			
1907				1	1	2	10		10	67	2	69	24	1	25	2		2						
1908				3		3	192	2	194	14		14				1		1	19	16	35			
1909				2	1	3	1126	55	1181	74	1	75	12	4	16	3		3	2	1	3			
1910	8	1	9	3		3	456	30	486	102	2	104	8		8	292	26	318						
1911				5	2	7	651	78	729	334	6	340	47	3	50	165	43	208						
1912	4	2	6	1	1	2	91	6	97	418	56	474	35	2	37	27	19	46	24	10	34			
1913	5		5	4	1	5	185	33	218	423	23	446	27	14	41	8	8	16	1		1			
1914	2		2	8	7	15	126	6	132	252	29	281	21	2	23	23	5	28						
1915	1		1	184	51	235	228	14	242	107	7	114	16	2	18	142	14	156						
1916		1	1	65	9	74	258	32	290	56	12	68	38	11	49	154	72	226						
1917	1		1	4	1	5	124	28	152	97	15	112	37	7	44	78	31	109						
1918				179	148	327	37	13	50	53	9	62	30	18	48	19	6	25	22	17	39			
1919				183	93	276	143	28	171	4	3	7	10	3	13	4	6	10	5	11	16			
1920				38	11	49	18	7	25	40	9	49	39	12	51	37	14	51						
1921					2	2	54	49	103	59	36	95	40	23	63	22	4	26		2	2			
1922				1	2	3	9	16	25	22	18	40	70	21	91	1		1						
1923				2	1	3	16	26	42	19	8	27	24	10	34		3	3						
1924					1	1	11	11	22		1	1	2	19	21	1	1	2						
1925							1	11	12				1	8	9									
1926								1	1					9	9								1	1
Totals	43	9	52	691	334	1025	3751	450	4199	2460	257	2717	730	182	912	997	252	1249	78	57	135	4	1	5

Table 2 (Concluded)—Accumulated Simple Transverse Fissure Failures. Reported to January 31, 1927, by Years Rolled and by Mills

	Illinois			Inland			Lackawanna			Lorain			Maryland			Pennsylvania			Tennessee			All Mills		
YEAR	PRIOR.	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total	Prior	1926	Total
Unk.	98	11	109				14	2	16				1	1	2	2		2	2	18	20	201	49	250
1889																2		2				2	0	2
1890							2		2							5		5				7	0	7
1891							4		4							3		3				8	0	8
1892													1		1	2		2				5	0	5
1893													2		2							3	0	3
1894													1		1	3		3				10	0	10
1895							1		1							2		2				9	0	9
1896	1		1				4		4							3		3	1		1	9	0	9
1897							9		9				1		1	7		7				32	0	32
1898							21		21				1		1	7		7				47	1	48
1899							12		12				3		3	18		18				54	0	54
1900	1		1										6		6	11		11				40	0	40
1901	2		2				18	1	19				11		11							71	2	73
1902	1		1				2		2				32	1	33							133	1	134
1903	1		1										46	2	48				25		25	188	4	192
1904							9	7	16				15	3	18				189		189	273	11	284
1905	6		6				9		9	1	1	2	21	5	26	5		5	321	1	322	419	13	432
1906	4		4				2		2	5		5	47	2	49	1		1	49	1	50	202	19	221
1907	22		22				15	5	20				70	4	74				60		60	271	13	284
1908		1	1				4		4	1		1	2		2	1		1	32		32	269	19	288
1909	326	92	418				57	3	60				50	3	53	92	3	95	5		5	1749	163	1912
1910	1459	128	1587				102	2	104				90	2	92	104	5	109	77	15	92	2701	211	2912
1911	163	33	196				296	20	316				180	9	189	103	5	108	114	18	132	2058	217	2275
1912	687	198	885				724	25	749				126	12	138	24	11	35	76	5	81	2237	347	2584
1913	723	219	942				616	40	656	1		1	332	25	357	63	1	64	63	6	69	2451	370	2821
1914	139	46	185				539	53	592				115	6	121	99	9	108	112	29	141	1436	192	1628
1915	236	79	315				198	41	239				350	29	379	111	23	134	40	16	56	1613	276	1889
1916	341	107	448				61	17	78				243	68	311	14	3	17	132	35	167	1362	367	1729
1917	895	280	1175				67	21	88				415	96	511		1	1	83	22	105	1601	502	2303
1918	177	71	248				67	15	82				49	13	62	10		10	130	39	169	773	349	1122
1919	314	123	437				25	15	40				16	7	23	57	9	66	92	44	136	853	342	1195
1920	193	98	291				29	28	57							63	48	111	38	24	62	495	251	746
1921	80	38	118				34	14	48							41	34	75	29	10	39	359	212	571
1922	27	13	40	44	29	73	20	13	33				1		1	6	10	16	77	40	117	278	162	440
1923	20	40	60	3	3	6	74	62	136							24	13	37	48	38	86	230	204	434
1924	7	32	39	1	9	10	6	12	18				1	1	2	34	13	47	9	28	37	72	128	200
1925		11	11	1	4	5	1	19	20				4	12	16	12	7	19	9	49	58	29	121	150
1926		7	7		1	1		5	5					2	2		2	2		22	22		50	50
Totals	5923	1627	7550	49	46	95	3042	420	3462	8	1	9	2232	303	2535	929	197	1126	1813	460	2273	22750	4596	27346

Table 3—Rate of Accumulated Transverse Fissure Failures on Selected Roads from Year Rolled to January 31, 1927, by Mills and Years Rolled

(Basis of Rating Is Number of Fissures per 10,000 Tons of Rails Produced for Reporting Roads)

Year Rolled	Beth	Camb	Carn	Colo	Ill	Inl'd	Mary	Penn	Tenn	Lack	All Mills
1909	238.5	20.6	1.7	0.9	14.6		9.0	23.5	0.8	10.8	26.2
1910	75.5	20.4	0.9	33.1	50.0		12.9	16.1	9.9	7.2	28.8
1911	108.2	57.1	5.5	30.3	10.9		27.2	21.8	19.8	35.2	31.6
1912	12.4	53.8	4.9	7.5	33.8		41.2	4.4	6.6	61.1	28.3
1913	21.0	49.6	2.8	2.0	35.1		37.0	6.8	5.8	40.5	24.7
1914	20.4	44.8	3.4	3.7	18.0		41.9	19.2	8.1	56.8	22.1
1915	47.1	19.3	1.1	18.8	15.6		106.2	27.5	7.1	26.3	20.7
1916	46.8	10.2	4.2	31.3	18.6		34.0	19.2	18.7	6.6	19.0
1917	14.2	18.3	4.5	12.2	52.0		122.8	-	6.1	7.1	24.8
1918	7.7	20.4	4.8	5.3	9.6		21.3	14.7	17.9	8.2	10.4
1919	16.9	23.7	1.6	1.6	23.5		7.2	41.2	11.1	6.0	13.5
1920	6.4	18.1	4.0	6.4	10.4		0.0	22.3	5.6	3.4	7.7
1921	9.6	22.7	4.4	3.1	3.5		-	29.5	2.7	7.0	5.9
1922	5.5	8.6	8.6	0.2	2.0	13.6	-	2.0	6.2	2.6	4.8
1923	2.2	5.8	1.9	0.8	2.4	0.9	-	1.5	8.0	18.4	3.9
Aver.	33.9	29.8	3.5	12.1	20.4	6.7	37.8	12.8	8.3	20.3	17.9

Table 4—Fissured Rails to January 31, 1927, Inclusive, Segregated by Mill, Rail Letter and Weight of Section

Mill	Rail Letter												Weight of Section - lbs per yd.								
	A	B	C	D	E	F	G	H	I	J	K	Total	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-up	Total
Unknown	1	3	1	1								6		2	12	16					30
Altoona	121	115	146	134	119	86	16				2	739		5	693	176	4				878
Bethlehem	377	548	471	520	244	188	46	28	1	10	6	2439		26	358	1440	350	2	274	185	2635
Cambria	252	264	206	199	82	20	48	7				1078	1	5	83	1067			344		1500
Carnegie	47	105	102	105	72	29	10	8				478	1	29	102	390	4		143		669
Colorado	304	257	219	204	37	45	14	2	1		1	1084	2	429	672	63					1166
Dominion	16	19	25	16	16	7	1					100		20	113	2					135
German	1											1		4							4
Illinois	1826	1007	1060	606	500	511	473	23	7	5	1	6019		17	3902	1999	148		5		6071
Inland	3	10	9	15	10	8	11	10	2	3	1	82			61	3	1				65
Lacka.	1063	671	457	248	23	1	9	9	1	1		2483	5	240	74	585	1956	1	21		2882
Lorain		1									1	2			8	2					10
Maryland	335	290	278	338	112	24	34	15				1426		12	126	984	48		442		1612
Penna.	135	102	99	93	39	40	45	31	1	9	9	603		3	45	449	72	14	157		740
Penn.	311	238	129	102	99	58	104	27	1	26		1085	1	265	1042	76	14				1398
All Mills	4792	3620	3202	2581	1353	1017	811	160	14	54	21	17625	10	1057	7291	7252	2597	17	1386	185	19795

Appendix D

(5) CAUSE AND PREVENTION OF RAIL BATTERING

Collaborating With Committee V—Track

Hunter McDonald, Chairman, Sub-Committee; W. J. Backes, L. C. Fritch, E. A. Hadley, R. H. Howard, C. W. Johns, R. Montfort, W. H. Penfield, G. A. Phillips, W. P. Wiltsee, W. C. Barnes.

In response to inquiries made regarding the most promising lines of investigation to be taken up and methods to be followed, the following reply of August 1st was received from W. C. Cushing, Engineer of Standards, Pennsylvania Railroad:

"I am greatly obliged to you for sending me a copy of the minutes of your meeting and it occurs to me that it might be well to call your attention in this connection to the value which I think heat-treatment of steel rails will have in reducing the tendency to battering on account of the enhanced physical qualities.

"For instance, the few rails which we have received from the Bethlehem Steel Company display the following increases of heat-treated rails compared with untreated rails.

		Per Cent
(1)	Increase in elastic limit per sq. inch	52.4
(2)	Increase in ultimate strength per sq. inch	18.0
(3)	Increase in elongation by tensile tests	39.3
(4)	Increase in reduction of area of specimen tensile tests	141.1
(5)	Increase in angle of bend before rupture	343.5
(6)	Increase in number of drop test blows before breaking	10.0
(7)	Increase in Brinell hardness	23.5
(8)	Increase in resistance to impact (Izod)	50.0

"You will note the great increase in strength, ductility and toughness, while at the same time being greatly harder, all of which should assist in preventing battering."

In this connection, attention is again called to the last clause of Appendix C to the Rail Committee's report for 1926, reading as follows:

"Prevention of Rail Battering.—No rail which has been under observation by the writer in these tests has been found to be free from battering. Quite a number show excessive battering. On the other hand, a considerable number show a minimum amount of battering. End overflow is usually also missing on rail and joints of such minimum batter. In the writer's opinion, the best course to be pursued in prevention of rail battering or reducing its intensity, is to study carefully the cooling conditions and metallurgy of those rails which show the least tendency to batter and when the conditions which bring about this quality of minimum battering are discovered, some method of manufacture which will bring the output of the mill up to point of producing rails of that or even better quality should, if possible, be devised and put into practice. The price to be paid for such improved rail cannot be appropriately discussed here further than to say that it should be agreed on by the manufacturers and purchasers. There can be no question but that tremendous economies can be effected in maintenance of way expenses by improving the quality of the rail."

An analysis of the variations in battering of different rails on Mile 106, Chattanooga Division, N. C. & St. L. Railway, made by J. L. Fergus, Division Engineer, illustrates quite clearly the variation in the quality of the rails as well as the fact that improvement cannot be arrived at by manipulation of the chemical content alone. It also illustrates the tremendous saving to be accomplished if rail could be obtained which would show

an annual batter not in excess of .005 inches under an annual traffic of ten million gross tons. This study appears in Volume 28 of the Proceedings, pages 1391-1398, inclusive, under title "Discussion on Cause and Prevention of Rail Battering."

Through the courtesy of the Reading Company officials, every facility was provided for an inspection by the sub-committee of the battering of rails laid with "head-free" joints on that road between Philadelphia and Reading. At a joint meeting with a Sub-Committee of the Track Committee, held at that time, the opinion was generally expressed that a tapered gage is sufficiently accurate for statistical as well as service measurements and probably more accurate than any type of micrometer instrument. It was pointed out that one side of the tapered gage could be graduated into thousandths and the other into fractions of an inch.

At this meeting the following opinions were formulated with the understanding that they were subject to further action at a subsequent joint meeting of the two Sub-Committees:

(A) It was the general opinion that sufficient attention had not been in past years bestowed on the care of the rail during and after laying, such neglect generally taking the form of inadequate anchorage against creeping, improper expansion spaces, excessive bolt tensions, failure to check the bad effects of end overflow by sawing off and deferring too long the welding up of rail ends.

(B) It was recognized that the end overflow takes place not only with open joints but also where joints have been laid and maintained without expansion space. That in either case chipping may be greatly reduced by systematic and judicious readjustment of joints which are found open at rail temperatures ranging about 120°. To make such adjustments end overflow should be sawed off, after which bolts should be slacked and the rails allowed to come together. The bolts should then be tightened. By this method the proper distribution of expansion allowance may be improved. If, however, too much expansion allowance was made at the time the rail was laid, the difficulty can only be corrected by driving the rail up. It was declared desirable that members try out this plan and report results obtained toward the prevention of chipping.

(C) It was the unanimous opinion that rail ends which show a batter of 3/64" should be built up by the welding process. That building up should not be resorted to until a batter of at least 3/64" is shown to exist.

(D) That it is not economical to weld up rail ends out of face and that as the welders pass over the line welding should be limited to joints where the rail ends show on one side or the other of the joint a batter of 3/64" or more or excessive chipping.

(E) That where joints have been built up by the welding process metal which has adhered to the ends of the rail in the joint gap and which will interfere with expansive movement of the rail should be removed. That this subject is one which should be inquired into with a view of developing the costs and methods now in vogue for such removal of welded metal.

(F) That rail battering on high-speed tracks with mixed traffic usually in one direction may extend on the receiving rail to a considerable distance beyond the joint gap. In such cases the cost of labor and material required in welding up should be balanced against the cost of resawing and redrilling; the decision will also be influenced by the question whether the rail is of the maximum section likely to be used on the system or of a lighter section suitable for resawing and relaying on lighter traffic lines. If of maximum section welding up is more economical than resawing.

(G) It was the unanimous opinion that the general milling of rail ends in order of reduce chipping is not necessary; that the rolling back by the cambering rolls of fins produced by the hot saws can be prevented by better and more effective means than milling.

Subsequent to this meeting, Mr. Bronson furnished a description of the methods now being pursued at some mills in the sawing, cambering and finishing of rails which it is thought will prove of interest and value and is inserted at this point.

"The general practice regarding rail sawing and cambering varies considerably from mill to mill. After the rail bar which may be two, three or even four or more rail lengths long leaves the finishing pass, it travels along the saw runway roller line to the hot saws. Some mills saw singly; others saw all the rails in the bar at one time through the use of gang saws. The shape of the teeth varies from plant to plant, also the thickness of the saws. Some saw from the head to the base; others from base to head. Some have saws travelling clockwise; others counter-clockwise. The material in the saws also vary. All of these details effect the condition of the end of the rail, and also the condition and size of the burr.

After sawing, the rails enter a curving roll stand, known as the cambering machine. This consists of a pair of horizontal rolls, and one vertical roll in front and back of these. The function of the machine is to curve the rail so that the head is on the convex side of the curve to compensate for the difference in rate of cooling of the mass of metal in the head and base, and to make the rails come out more nearly straight from the cooling beds to minimize gagging.

"At some of the mills the vertical rolls are or were fixed, so that as the rail travelled through, the burrs on the rail end on top of the head were mashed down and made it difficult to chip and file them properly. The plant at Gary introduced a steel plate just ahead of the cambering machine which was supposed to act as a scrapper to remove the head burr, on account of its saw tooth construction. This did more damage than good as it scrapped off the burr and bevelled the ends also of many rails.

"Some mills have now introduced automatic adjusting vertical rolls which permit the burred end of the rail to pass through the machine without in any way touching the burr, and commence to tighten up on the rail only when about 1½ to 2 inches of the rail has passed through the machine. This leaves the saw burr standing up on the edge of the rail end and makes it easy to chip off, and we are now getting an excellent finished rail end from several mills we deal with. The practice will probably be universal before long at all of the mills. This obviates one necessity for milling. The other, of course, is off-squaring, which can be controlled by proper supervision of the inspecting forces."

The advantages to be obtained from lubrication to promote movement of rail through the joints under excessive bolt tensions are considered worthy of further investigation.

It is Mr. McDonald's intention to continue his observations on the relative rate of battering of high and low carbon rail now being carried out at two points on the Atlanta Division of the N. C. & St. L. Railway, also to make a study of the wear on each side of the joint gap between fishing surfaces and the head of the rail on the joints on the test mile 106, Chattanooga Division, where the arrangement of ties under the joint has not been disturbed since the rail was laid. The intention is to endeavor to find the relative effect on the fit of the joints when laid suspended, supported or neutral, as outlined in monograph, Appendix C, heretofore referred to.

Exhibit 1 shows the manner in which the monthly observations for the above mentioned test to determine the relative rate of batter between high and low carbon rail, are made and recorded. Exhibit 2 is a graph of the result of these tests from the time they were instituted in February, 1926,

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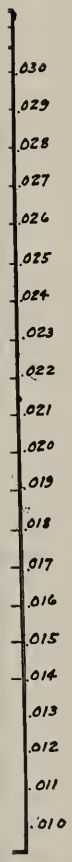
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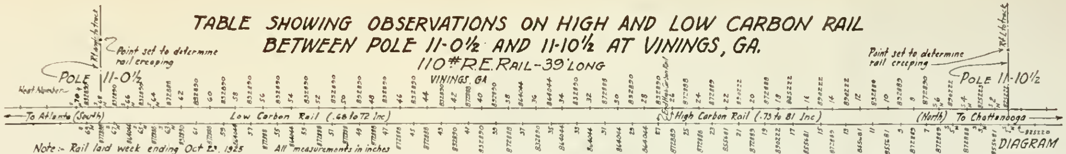
TABLE SHOWING OBSERVATIONS ON HIGH AND LOW CARBON RAIL BETWEEN POLE 11-0½ AND 11-10½ AT VININGS, GA.

110# R.E. RAIL – 39' LONG

N. C. & St. L. Ry
Office of Division Engineer
Atlanta Division
Atlanta, Ga
Drawing 723-4-76.



DIAGRAM

Note: The rail north of the joint has the same number as the joint itself.

YEAR - 1927

Note:- Rail laid week ending Oct 2?, 1925. All measurements in inches

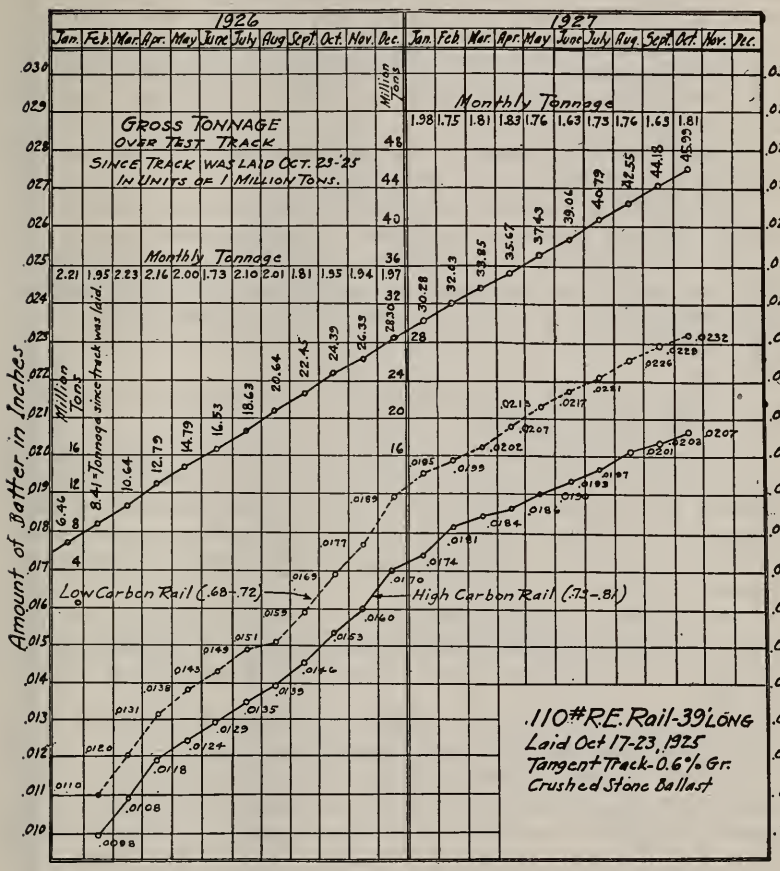
Rail No.	% Carbon	% Mang.		Joint No.	July Batter N.	July Batter S.	July Joint Gap	July Remarks	Aug. Batter N.	Aug. Batter S.	Aug. Joint Gap	Aug. Remarks
					Temperature 118° Fahrenheit			Bolts tight unless otherwise noted	Temperature 108° Fahrenheit			Bolts tight unless otherwise noted
1	77	87	High Carbon Rail (See diagram above)	1	014	023	1/32		013	023	0	
2	76	85		2	013	023	0		019	026	0	
3	74	85		3	033	003	0	This joint welded	.032	003	0	Welded
4	80	89		4	023	023	0		024	035	0	
5	71	74		5	018	018	0		018	020	0	
6	74	90		6	010	016	0	This joint welded	012	017	0	Welded
7	73	74		7	014	016	0		014	018	0	
8	74	77		8	019	022	0	Total gross tonnage	019	022	0	Total gross tonnage
9	73	74		9	013	013	0	passing over tracks	013	013	0	passing over tracks
10	70	78		10	017	016	0	NC&StL 904 032	018	.016	0	NC&StL 960 111
11	74	85		11	010	020	0	L&N 824 886	016	.020	0	L&N 796 922
12	70	78		12	017	.025	0	Total (tons) 1 728 918	017	025	0	Total (tons) 1 757 033
13	74	85		13	024	018	0	Add 10 762 200	025	014	0	Add 12 491 618
14	74	90		14	019	024	0	Since Jan 1 1249 418	019	025	1/64	Since Jan 1 14 248 65[illegible]
15	73	74		15	030	033	1/16		031	034	1/32	
16	74	90		16	012	019	1/32		013	020	0	
17	74	85		17	019	015	0		020	016	0	
18	76	84		18	026	011	0		020	011	0	
19	74	90		19	018	020	3/64		019	020	4/32	
20	71	74		20	013	019	0		013	.019	0	
21	73	74		21	018	021	0		019	.022	1/32	
22	74	90		22	022	025	5/64		022	025	7/64	
23	74	85		23	024	020	0		027	020	0	
24	73	74		24	027	011	0		027	011	0	
25	71	74		25	016	.022	0		016	022	0	
26	71	74		26	020		0		.020		0	
27	73	74		27	026		0		.027		0	
			Average		0194	.0199	1/4"	East Rail 9/64"; West Rail 7/64"	0193	0203	7/32"	East Rail 7/32"; West Rail 1/8"
			Std Exp Allowance				0"					
			Condition of Rails as to Creeping					NONE				NONE
			Low Carbon Rail (See diagram above)	26		024				024		
				27		027				027		
28	68	70		28	023	024	0		022	025	0	
29	69	76		29	033	022	0		033	032	0	
30	68	70		30	018	020	0		.018	020	0	
31	69	76		31	.030	025	0		.030	025	0	
32	71	74		32	012	020	0		.012	021	1/32	
33	69	76		33	017	018	1/32		018	019	1/32	
34	68	70		34	023	013	0		025	013	1/64	
35	69	76		35	020	017	1/32		021	018	0	
36	69	76		36	020	024	3/32		.020	.024	1/8	
37	68	70		37	031	013	3/64		.032	013	1/64	
38	69	76		38	017	020	0		018	020	0	
39	71	74		39	013	031	0		.014	031	0	
40	68	70		40	027	018	0		027	.019	0	
41	68	70		41	018	021	0		018	.022	0	
42	71	74		42	020	030	0		.020	031	0	
43	68	70		43	024	018	0		.024	018	0	
44	68	70		44	020	025	1/32		020	020	1/16	
45	71	74		45	021	024	0		.022	025	0	
46	68	70		46	014	014	1/32		.015	014	1/32	
47	71	74		47	027	021	1/16		027	021	1/16	
48	68	70		48	032	025	3/64		032	.025	1/32	
49	71	74		49	012	026	0		012	026	0	
50	68	70		50	032	024	0		032	024	0	
51	71	74		51	020	018	0		021	018	3/32	
52	68	70		52	031	024	3/64		032	025	1/32	
53	71	74		53	020	025	0		026	.026	1/8	
54	68	70		54	018	025	1/32		018	026	1/8	
55	69	76		55	020	019	0		.021	.018	1/16	
56	68	70		56	020	019	9/64		027	019	1/32	
57	71	74		57	019	.019	1/32		019	013	0	
58	68	70		58	024	021	0		025	.022	0	
59	69	76		59	030	018	7/32		030	018	7/64	
60	68	70		60	026	023	0		026	024	0	
61	71	74		61	023	034	0		024	034	0	
62	68	70		62	018	032	0		019	.033	0	
63	68	70		63	022	018	0		023	.016	0	
64	71	74		64	010	024	0	This joint welded	.012	023	0	Welded
65	71	74		65	020	013	0		.021	012	0	
66	68	70		66	022	019	0		.022	019	0	
67	69	76		67	027	020	1/16		.027	020	1/16	
68	68	70		68	020	027	3/64		.020	028	1/32	
69	71	74	Average		0224	0219	3/64"	East Rail [illegible]; West Rail 3/8"	0228	0224	[illegible]	East Rail [illegible]; West Rail [illegible]/64"
70	68	70	Std Exp Allowance				0"				0"	
			Condition of Rails as to Creeping					NONE				NONE
			Average of High & Low Carbon Rail		0212	0212			0217	0216		

Joint No.	Sept. Batter N.	Sept. Batter S.	Sept. Joint Gap	Sept. Remarks	Oct. Batter N.	Oct. Batter S.	Oct. Joint Gap	Oct. Remarks
	Temperature 112° Fahrenheit			Bolts tight unless otherwise noted	Temperature ° Fahrenheit			Bolts tight unless otherwise noted
1	016	024	0		.016	026	1/64	
2	020	026	0		020	026	0	
3	033	003	0	Welded	034	003	0	Welded
4	025	025	0		023	026	0	
5	018	.020	0		019	020	0	
6	013	013	0	Welded	018	021	1/32	Welded
7	014	.016	0		015	016	0	
8	019	022	1/32	Total gross tonnage	020	026	1/16	Total gross tonnage
9	014	.013	0	Passing over tracks	014	.013	0	Passing over tracks
10	013	.016	0	NC&StL 833 421	010	017	0	NC&StL 923,421
11	016	.020	1/32	L&N 799 132	017	020	1/64	L&N 891,841
12	017	026	0	Total (tons) 1 632 553	017	027	0	Total (tons) 1,814,762
13	035	014	0	Add 14 248 651	035	014	0	Add 15,881,204
14	019	026	1/32	Since Jan 1 15 88 204	019	027	3/64	Since Jan 1 17,695,966
15	.031	034	1/16		031	034	3/32	
16	014	021	1/16		014	022	3/64	
17	021	016	0		022	016	0	
18	026	011	1/16		027	011	3/32	
19	020	020	3/64		020	020	3/64	
20	013	.020	0		013	021	0	
21	019	022	0		020	022	0	
22	022	025	3/32		022	026	9/64	
23	.028	020	0		028	030	1/64	
24	028	011	0		028	011	0	
25	016	022	0		.016	022	1/32	
26	020		0		021		0	
27	027		0		028		1/32	
Average	0202	0204	27/64	East Rail 9/64"; West Rail 9/32"	.0206	.0208	31/64"	East Rail 5/16"; West Rail 31/64
Std Exp Allowance								
Condition of Rails as to Creeping				NONE				None
26		025				026		
27		028				028		
28	023	023	0		023	026	0	
29	034	022	1/16		024	022	3/64	
30	018	020	0		018	021	0	
31	030	023	0		.030	026	0	
32	012	022	3/64		012	023	3/64	
33	018	019	1/32		018	019	1/64	
34	026	014	0		026	014	1/8	
35	021	019	3/64		022	018	0	
36	020	023	7/32		020	026	3/32	
37	033	013	1/32		034	013	3/64	
38	018	020	0		018	020	0	
39	.014	032	0		014	032	3/32	
40	027	020	1/8		027	021	7/32	
41	.018	023	0		019	024	0	
42	021	032	0		.021	028	1/8	
43	024	018	0		024	018	3/64	
44	020	025	0		020	025	1/32	
45	023	.023	1/32		.026	026	7/32	
46	016	014	1/32		017	015	1/64	
47	028	021	1/16		029	021	3/64	
48	033	025	0		035	026	3/64	
49	013	027	0		013	027	0	
50	.032	024	0		023	.026	3/64	
51	.021	019	5/64		022	010	3/64	
52	033	025	3/64		038	023	3/64	
53	026	027	3/64		.027	027	1/16	
54	018	025	0		018	026	9/64	
55	021	.019	1/8		021	020	7/64	
56	[illegible]	.020	1/64		028	020	3/64	
57	[illegible]	.018	0		019	.010	1/32	
58	.025	.022	0		.026	022	0	
59	[illegible]	.020	3/32		.030	020	3/32	
60	.026	.024	3/64		026	024	3/64	
61	[illegible]	.035	3/32		024	030	3/32	
62	[illegible]	.033	0		.021	024	0	
63	022	016	0		024	016	0	
64	.013	026	[illegible]	Welded	016	027	1/32	Welded
65	021	013	0		.021	.018	0	
66	022	020	1/16		.032	030	3/64	
67	.02[illegible]	021	[illegible]		.028	021	3/64	
68	020	023	[illegible]		.030	030	1/32	
Average	[illegible]	.0226	1 3/64"	East Rail 41/64"; West Rail 19/32"	.0230	.0228	9 3/4"	East Rail 1 23/64"; West Rail 1 1/4"
Std Exp Allowance			0"				4 1/4"	
Condition of Rails as to Creeping				NONE				None
Average of High & Low Carbon Rail	0220	.021[illegible]			.0232	.0221		

	Nov. Batter N.	Nov. Batter S.	Nov. Joint Gap	Nov. Remarks	Dec. Batter N.	Dec. Batter S.	Dec. Joint Gap	Dec. Remarks
	Temperature ° Fahrenheit			Bolts tight unless otherwise noted	Temperature ° Fahrenheit			Bolts tight unless otherwise noted
Average (High Carbon Rail)				East Rail; West Rail				East Rail; West Rail
Average (Low Carbon Rail)				East Rail; West Rail				East Rail; West Rail

Exhibit 2

Graph of Progressive Batter for High and Low Carbon Rail. Vinings, Ga. (Between Poles 1-0½ and 11-10½)



up to September, 1927. Another line on the graph shows the approximate gross tonnage and the figures, the monthly and accumulative tonnage.

Exhibit 3 is a graph similar to Exhibit 2 and covers observations more lately instituted than those on Mile 11 on 110-lb. rail of so-called low carbon only (.68 to .72) but showing the total batter and tonnage since the rail was laid in October, 1924, on Mile 46, Atlanta Division. Comment on these results will be withheld for the present, but the observations will be continued. However, it is important to state that the test rails on Mile 11 are located on a long grade of .6 per cent where all southbound trains run at high speed, while northbound freight trains are slowed down and the use of sand is common. Mile 46 is at the bottom of a long grade averaging .6 per cent southbound where all trains run at high speed in both directions but where the use of sand is rare.

Consideration of the matter of joint mill and track tests suggested by Chairman McDonald brought out the following:

That the difference in hardness in rails of the same heat could not be reliably determined by the use of any form of portable hardness tester.

That such differences could only be brought out by the use of the large ball Brinell machine and mill conditions seem to preclude the practicability within reasonable cost of determining with the large ball machine the relative hardness near the ends and on the side of the head of each rail of a given heat.

That the difficulty regarding the proposed mill investigations was one of cost rather than of possibilty.

It was fully recognized that ladle analysis gives no reliable index to the chemical content of the rails at their ends and that for conclusive information as to the effect of chemical constituents toward prevention of rail battering it is essential that the actual carbon and manganese contents of the metal at the ends of the rail under investigation should be known with reasonable certainty.

That resistance of rail to flange wear is no more important than its resistance to battering under traffic but that possibly the improvement of the quality of the rail in one direction may result in improvement also in the other.

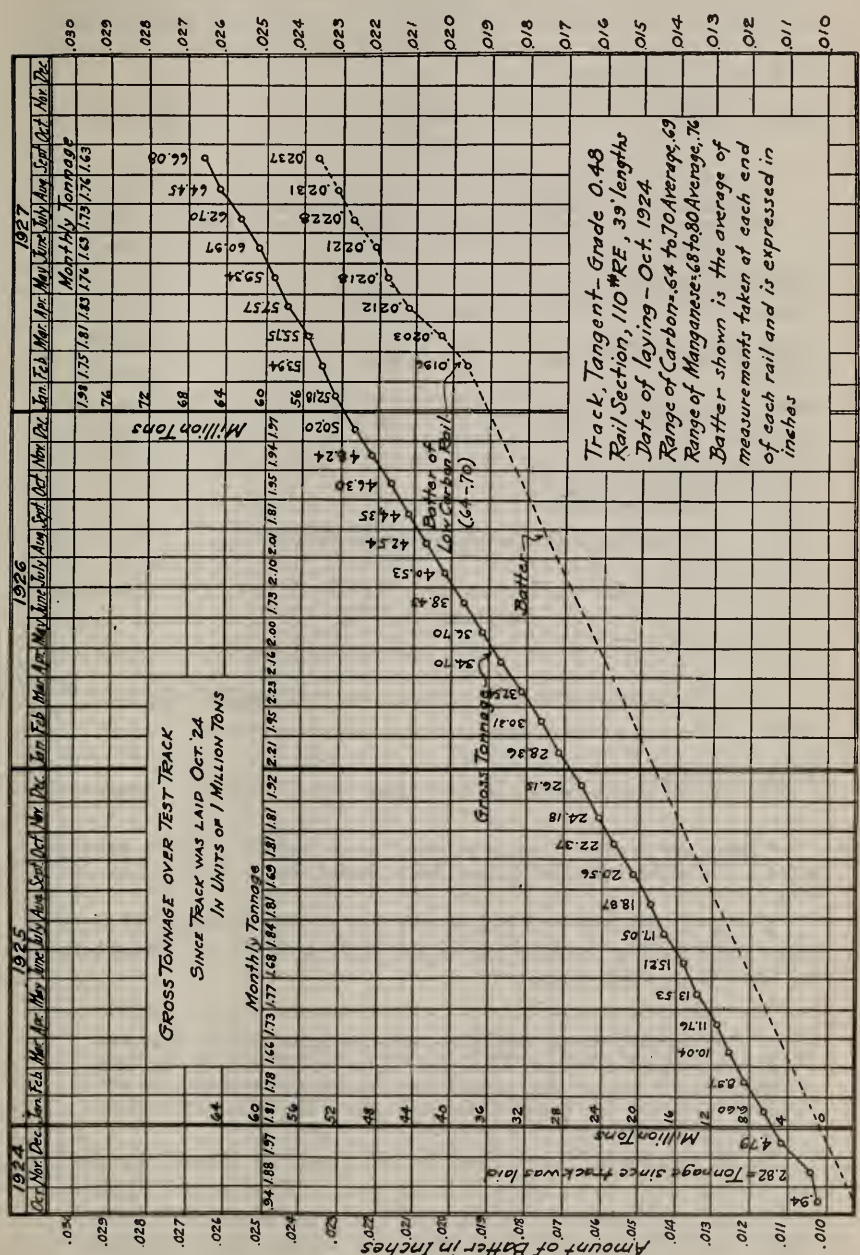
That probably more rails are removed from track as a result of rail battering than from abrasion of the outside rail on curves.

That the proposed combined mill and track test which will cover both conditions of manufacture and service in the track is very desirable and should be brought to the attention of the joint committee of experts representing the Manufacturers' Technical Committee and the Rail Committee of the American Railway Engineering Association for its careful consideration in connection with the matter of improvement of the quality of rails which said joint committee now has under investigation. This matter will be presented to the Board of Direction for its determination.

It was arranged that Messrs. Markley of the Rail Joint Company and Wrenshall of the Reading Company, would jointly make batter measurements on head free and angle bar joints laid about the same time and carrying approximately the same traffic. These observations are to include such an equal number of joints of each type as these gentlemen may determine. They are also to include information as to the temperature of rail, width

Exhibit 3

Graph of Progressive Batter for Low Carbon Rail. M.P. 46.2-46.3, W. & A. Div.



of joint gap, condition as to chipping and condition as to movement or non-movement of rail through the joints, these results to be reported to all members of both sub-committees.

The following is a summary of the data submitted with this report and for comparison there has also been added to the table batter measurements made on 75 tangent rails on the test Mile 106 of the Chattanooga Division, N. C. & St. L. Railway.

Reading Railroad Measurements, Rail Laid April, 1924, Measured August 11, 1927

Number and Description of of Joints	Batter on Receiving End	Joint Gap	Rate of Batter Per Mo.	No. of Joints Chipped	No. of Joints Frozen	Approx. Annual Gross Tonnage
50-Continuous, Head Free, 24" long, 130-lb. R. E. Rail.....	.0100 x	$+\frac{15.34}{64}$	.00024	4	17	8,000,000 to 10,000,000
50-100% Head Free Angle Bars, 24" long, 130-lb. R. E. Rail.....	.0131 xx	$+\frac{9.6}{64}$	.00032	3	21	8,000,000 to 10,000,000
50-100% Head Contact Angle Bars, 24" long, 130-lb. R. E. Rail.....	.0192 xxx	$+\frac{8.62}{64}$	.00047	6	32	8,000,000 to 10,000,000

x — .0011 = Batter on leaving end.
xx — .0017 = Batter on leaving end.
xxx — .0019 = Batter on leaving end.
$+\frac{4}{64}$ = A.R.E.A. Recommended Expansion Allowance for 90° Rail Temp.

N. C. & St. L. Railway Measurements, Rail Laid June, 1923, Measured September 15, 1927

Number and Description of Joints	Total Batter	Rate of Batter Per Month	Approx. Annual Gross Tonnage
x 67-Head Contact Angle Bar Joints, 24" long, 110-lb. R. E. Rail, Single Track Tangent..	.0260	.00051	12,000,000

x These are of the 75 joints referred to as Exhibit 1 in Mr. Fergus' paper. The eight joints which had been welded up are excluded in each case.

The batter measurements include only that for the receiving end of the rails on the Reading tracks, while on the N. C. & St. L. it includes both, the latter being single track.

The following is quoted from the letter transmitting this report:

> "It appears to me that these measurements indicate that our previous belief that the 'Head-Free' Continuous joint is the best type of joint for our use, is well founded, because according to our figures there is less batter to the rails where the 'Head-Free' Continuous bars are used than with the other types."

So far as battering is concerned, the claim made by Messrs. Wrenshall and Markley above quoted seems to be sustained by these figures. It should be borne in mind, however, that the number of observations made is hardly enough upon which to base a final conclusion. Further and more extensive

tests should be made. These should also include measurements on rail of lighter sections than 130 lb.

The only discussion of the report of Messrs. Wrenshall and Markley received was submitted by Mr. Bronson of the New York Central on October 5th and his letter is here reproduced.

> "With reference to your letter of Sept. 24th, file 15-V-3-O, and attached report of measurements of joints on the Philadelphia & Reading, made by Mr. Wrenshall.
>
> "While these measurements apparently make it appear that the continuous head-free joints are superior, yet there are several things which are not explained in studying over this data.
>
> "For instance, on joints 32 and 33 for the continuous head-free type, the batter on the receiving end is 3/128 compared to 1/128 between the two joints. The batter on the leaving ends does not indicate that one rail is necessarily softer than the other. We find a similar case between joints 48, 49 and 50 of this same series.
>
> "On the 100 per cent head-free joints, compare joints 8 and 9; 23 and 24; and 37 with 38.
>
> "For the 100 per cent angle bar joints, compare joints 1 with 2; 23 with 24; and 40, 41 and 42.
>
> "It seems to me that either these individual rails are soft, the expansion is too great, or the ballast, ties and sub-soil at the particular joints are not the equal of that at other joints. Expansion does not seem to offer the solution, neither does the softness or hardness of the rail, comparing leaving and receiving end batter for any individual rail. It looks as though it is a combination of all of these conditions mentioned.
>
> "One other point—where the measurements are down to 1/128 inch which, of course, is essential, and the reading deviates slightly one way or other, the observer may favor the reading of batter at one joint in one direction and in the opposite direction for the next one which would make the difference in batter appear more than it really is between individual joints.
>
> "These points occurred to me and I thought I would write you for what consideration you may think they are worth."

At the Chairman's request, Mr. Wrenshall removed a pair of "Head-Free" Continuous joint bars from the southward track at Pole 31/7 north of Mingo, at which point the rail was laid in 1922. Mr. Wrenshall's observations as to the wear of the plates follow:

Outside Plate

Receiving end worn smooth on top and on side of fillet. Leaving end worn for full length on top but little wear on side of fillet except for 3 inches near end of rail. Part of plate fitting top of base of rail worn slightly for full length but hardest on leaving end for first 7 inches from end of rail. Part of plate fitting under base of rail worn only under receiving end.

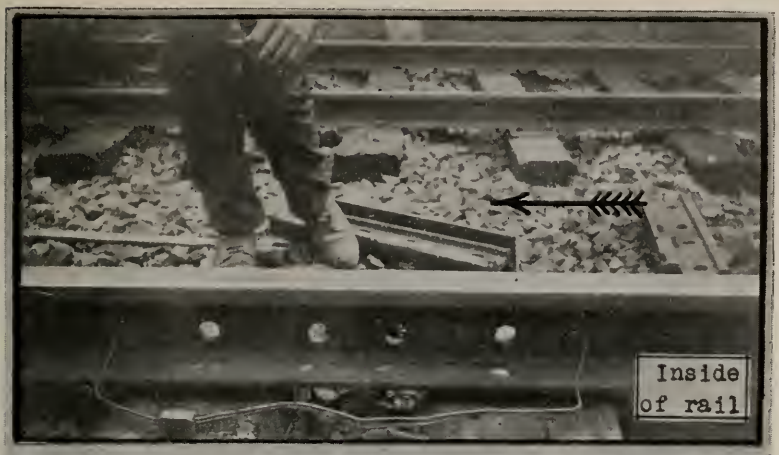
Inside Plate

Receiving end worn smooth on top and on side of fillet for full length but much harder on first 6 inches from end of rail. Leaving end worn uniformly on top and on side of fillet except no wear on first 1½ inches at end of plate. Part of plate fitting top of base of rail worn for full length of receiving end and on leaving end only for first 3½ inches from end of plate. Part of plate fitting under base of rail worn for full length of leaving end and on receiving end only for first four inches from end of plate."

The views on following pages are a part of Mr. Wrenshall's report.

Regarding observations which have been in progress since July, 1923, on 110-lb. rail laid on Mile 106, Chattanooga Division, N. C. & St. L. Rail-

Arrows show direction of traffic.



Arrows show direction of traffic.

A

way, reference is made to monograph, Appendix C to Report of Rail Committee, Vol. 26 of the Proceedings, and to Exhibit "O," which is a statement of the batter measurements made Sept. 15, 1927, on every joint which has been under observation heretofore. This statement also shows what has been termed, for want of a better name, the "The Head Fishing Wear" at each rail and for each joint. For these measurements a taper gage was used and each joint was jacked up slightly so as to show the entire fishing wear.

This Exhibit also shows the dates upon which rail ends have been welded up on account of battering and such loose bolts as were found at that time, and the rails which are laid on tangents and on curves. A profile of this test track showing the grades and alignment will be found in Exhibit "C" to Appendix C, above mentioned.

A considerable portion of this test track has been overhauled in 1927 and while the track was being lifted a number of the ties were respaced and some renewed. This respacing has, of course, resulted in changing the relationship between a number of the ties and the joints to which the ties were adjacent. The original relationship of ties to the rail joints is shown on Exhibit "A" of Appendix C, above mentioned.

However, position of the ties at a large number of these joints, remains undisturbed. Exhibit "P" has been prepared with a view of showing the relationship between the batter and the head fishing wear as affected by the position of the rail joint with reference to the ties on each side. Suspended, supported and neutral joints, as well as the combination of all three of these types, are shown on the graph by appropriate variations in the lines. The number at the angles in these lines show the number of rail ends corresponding to a given head fishing wear and batter.

This graph seems to support the theory heretofore held by many and concurred in by the Chairman that with a well designed and manufactured angle bar joint it makes little difference whether the joints are suspended, supported or neutral. Further observations should be made.

In this connection, we are reproducing here the answer of G. J. Ray, Chief Engineer, Delaware, Lackawanna and Western Railroad, to Question 17 of the questionnaire sent out in 1925, and now appearing on page 995 of the Proceedings for 1926:

> "We have found by using a plate 27 inches long by 12¾ inches wide by ¾ inches thick on two ties and supporting the joint coupled with the girder bars that batter is reduced to practically nothing."

This is a very important statement and well worthy of consideration.

In the report of the Chairman at the 1927 convention, beginning at the bottom of page 1352 of Volume 27 of the Proceedings, reference is made to test of lubricated joints. In these tests it was shown that lubrication did not accelerate the movement of the rail through the joint. Reference was also made to a new test with graphite grease, known as Gredag, containing 50 per cent of graphite. Sixteen joints were so treated last spring and examination this fall shows no better results than those heretofore obtained with oil and other greases. Fourteen joints were found frozen, one with one end frozen and one with both rails moving. The material did not prevent corrosion.

In this connection, it will be noted from the 1927 report that when the lubricated joints were removed bright spots were found opposite the bolt

holes which were attributed to the fact that in punching the joint bars the bars are widened opposite the bolt hole resulting in the contact of the fishing surfaces being limited to these high spots.

In our trip over the Reading this matter was brought up and the statement made by a number of those present to the effect that while this bulging at the bolt holes may be present with the smaller weights of rail there is no such bulging in the joint bars punched for the 130-lb. rail.

This report is submitted as one of progress only.

Exhibit O

N. C. & ST. L. RAILWAY

MEASUREMENTS OF BATTER AND HEAD FISHING WEAR ON MILE 106, CHATTANOOGA DIVISION, TAKEN SEPTEMBER 15th, 1927

	Batter		*Head Fishing Wear*		
Rail No.	*No.*	*So.*	*No.*	*So.*	*Remarks*
1 Tan.	25	10	0	15	S. end welded 4-29-26
2	35	25	10	10	
3	20	15	5	5	N. end welded 4-29-26
4	30	20	5	15	
5	15	25	5	10	
6	20	25	0	15	
7	30	20	0	20	
8	20	25	10	0	
9	20	25	0	0	
10	20	20	10	30	One loose bolt in Joint 12
11	20	30	15	5	
12	25	30	5	5	
13	20	25	0	0	
14	20	25	20	10	
15	25	20	5	0	
16	20	25	5	10	
17	20	25	0	5	
18	20	35	0	5	
19	25	25	0	0	
20	20	40	5	5	
21	20	35	10	5	
22	35	40	5	5	
23	30	30	5	0	
24	35	25	10	10	
25	20	20	10	5	
26	20	25	5	10	
27	25	25	0	0	
28	20	20	5	5	
29	20	25	15	5	
30	20	25	15	0	
31	25	25	5	0	S. end welded 4-30-26
32	20	30	5	10	
33 Tan.	15	30	15	5	N. end welded 4-30-26

Note: Measurements shown are thousandths of one inch.

The rail south of the joint has the same number as the joint itself. See "Chart showing plan of numbering joints and rails." Exhibit A, Page 518, Vol. 27, Proceedings.

Batter and head fishing wear measurements for any joint should be obtained by combining even or odd figures as shown connected by diagonal lines above. Thus, the average batter for Joint No. 7 is half of 30 plus 25 and the average head fishing wear for the same joint is half of 0 plus 10.

A.R.E.A. COM. № 4-RAIL SUB-COM. № 5 1927

P

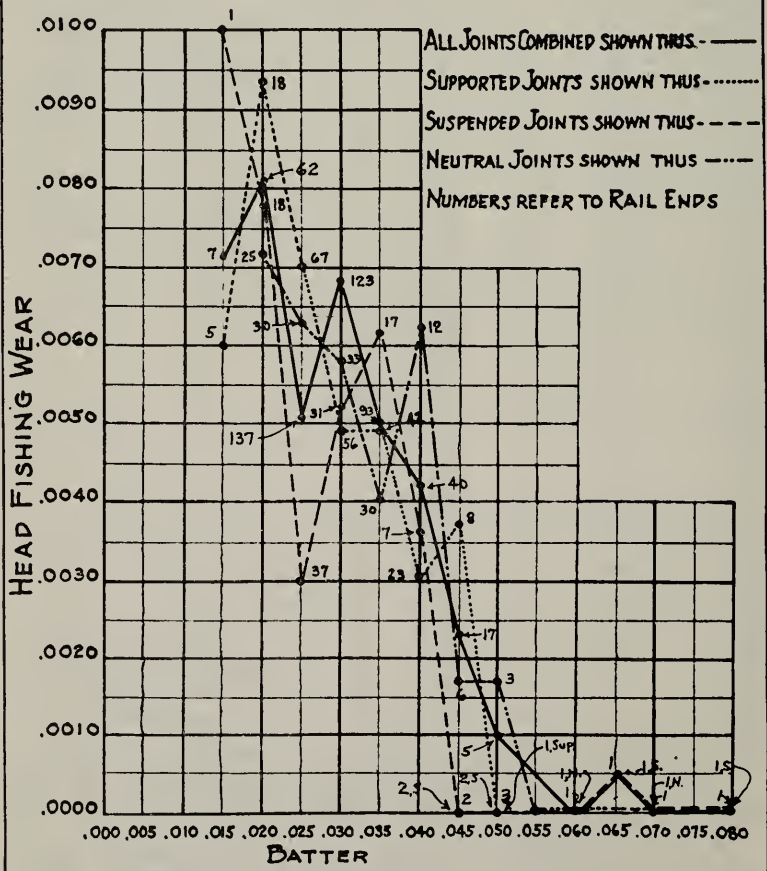
M.P. 105-106, CHATTANOOGA DIV.

RELATION BETWEEN

BATTER AND HEAD FISHING WEAR

ALL WELDED RAIL ENDS EXCLUDED

ALL JOINTS, WHOSE CLASSIFICATION (Suspended, Supported, Neutral) HAS CHANGED SINCE FIRST INVESTIGATION, ARE ALSO EXCLUDED.



REPORT OF COMMITTEE V—TRACK

J. V. Neubert, *Chairman;*
J. B. Akers,
W. G. Arn,
W. H. Bevan,
C. W. Breed,
H. W. Brown,
W. G. Brown,
E. W. Caruthers,
H. G. Clark,
J. W. DeMoyer,
J. E. Deckert,
L. W. Deslauriers,
E. B. Entwistle,
J. M. Fair,
C. J. Geyer,
F. S. Hales,
W. J. Harris,
O. F. Harting,
E. T. Howson,
C. R. Harding, *Vice-Chairman;*
T. T. Irving,
H. D. Knecht,
E. R. Lewis,
J. de N. Macomb,
F. H. Masters,
C. M. McVay,
J. C. Mock,
J. B. Myers,
A. J. Neafie,
G. A. Peabody,
W. H. Petersen,
O. C. Rehfuss,
I. H. Schram,
G. J. Slibeck,
G. M. Strachan,
J. B. Strong,
E. D. Swift,
J. R. Watt,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report on the subjects assigned as follows:

(1) Revision of Manual (Appendix A).

(2) Make critical review of the material now appearing in the publications of the Association relating to curve elevation; ascertain existing views and practices of the railways, and recommend such changes as are found desirable (Appendix B).

(3) Continue the study of detailed plans of switches, frogs, crossings and slip switches, including self-guarded frogs (Appendix C).

(4) Continue the study of track construction in paved streets (Appendix D).

(5) Study and report on design and specifications for foundations under railway crossings; also proper methods for tie spacing and timbering under railway crossings (Appendix E).

(6) Study and report on methods of reducing rail wear on curves, with particular reference to oiling the rail or wheel flanges, collaborating with Committee IV—Rail (Appendix F).

(7) Make critical review of material in former Proceedings with respect to the cause and effect of brine drippings, collaborating with Committee IV—Rail, and Committee XV—Iron and Steel Structures (Appendix G).

(8) Outline of work for ensuing year. (The Committee's recommendations are given under "Recommendations for Future Work.")

Action Recommended

1. That the changes in the Manual outlined in Appendix A be approved and that revised version be substituted for the present recommendations in the Manual.

2. That the conclusions in Appendices C, D and E be adopted as recommended practice and published in the Manual as outlined in these reports.

3. That further data as outlined in Appendices C and E, also reports as outlined in Appendices B, F and G, be received as information only.

Recommendations for Future Work

(1) Revision of Manual.

(2) Continue critical review of the material now appearing in publications of the Association relating to curve elevation; ascertain existing views and practices of the railways; and recommend such changes as are found desirable.

(3) Continue the study of detailed plans of switches, frogs, crossings and slip switches.

(4) Continue the study of track construction in paved streets.

(5) Continue study and report on design and specifications for foundations under railway crossings; also proper methods for tie spacing and timbering under railway crossings.

(6) Continue study and report on methods of reducing rail wear on curves, with particular reference to oiling the rail or wheel flanges, collaborating with Committee IV—Rail.

(7) Continue critical review of material in former Proceedings with respect to the cause and effect of brine drippings, collaborating with Committee IV—Rail, and Committee XV—Iron and Steel Structures.

(8) Outline of work for ensuing year.

Respectfully submitted,

The Committee on Track,

J. V. Neubert, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. V. Neubert, Chairman, Sub-Committee; C. R. Harding, W. G. Arn, C. W. Breed, E. W. Caruthers, O. F. Harting, E. R. Lewis, C. M. McVay, J. B. Myers, J. R. Watt.

The Committee recommends the following changes in the Manual and to adopted plans:

All future plans and specifications of the Track Committee to have the initials "A.R.E.A." (standing for American Railway Engineering Association) placed thereon in a conspicuous manner, preferably above main title. Existing plans and specifications are to be modified in this respect only when reprinted.

Withdraw Plan No. 953, Details of Movable Point Crossings, angles 8 deg. 10 min. to 15 deg, 30 min., inclusive, dated November, 1926, adopted March, 1927, and substitute plan of the same number (953) entitled A.R.E.A. Details of Movable Points for Curved Crossings, angles 8 deg. 10 min. to 15 deg. 30 min., dated revised November, 1927.

It has been found desirable for movable points for curved crossings for range of angles covered by this plan to recommend carrying the points to 3 inches from the center of the knuckle rail so as not to leave a gap as large as permitted by the 5 inch dimension specified on plan adopted March, 1927, which change has made necessary the introduction of a special cast steel clip for interlocking, a design for which is detailed on the plan. It has also been found desirable to modify the plan as to planing to afford a bearing of the wheel on the movable point closer to the end.

Withdraw Plan No. 983, Solid manganese steel frogs for 7 inch and 9 inch girder rails, dated November, 1926, adopted March, 1927, and substitute plan of the same number (No. 983) entitled A.R.E.A. Solid manganese steel frogs for 7 inch and 9 inch girder rails, dated revised November, 1927.

Revised plan No. 983 shows more information. Table of arm lengths now includes No. 4 frog, and further dimensions for other frogs are given in this table.

Revisions to plans since last presentation:

Plans No. 305 and No. 308:

In section show clip for fastening base plate, change diameter of clip bolt from 7/8 inch to 3/4 inch.

This change recommended to make frog and crossing plans uniform in this respect.

Plan No. 771-B:

Change first sentence of Note 6 to read: "All special length splice bar bolts for connecting adjoining rails to be furnished with crossing and to have square nuts and spring washers unless otherwise specified or required."

Plan No. 773:

Change last paragraph of specifications relating to special length splice bar bolts to read:

"All special length splice bar bolts for connecting adjoining rails shall be furnished with crossing, and to have square nuts and spring washers unless otherwise specified or required. Splice bars for connecting adjoining rails not to be furnished unless specified, or unless special bars are required."

Above changes recommended to make these plans consistent with later plans adopted.

Plan No. 640:

Omit classes "H" and "J," as lengths given do not allow proper tie spacing.

The Committee has under consideration a new set of dimensions for heavy sections of rail and plans to submit these at a later date.

Plans No. 643 and No. 670:

Omit classes "H" and "J," for same reasons explained above in connection with plan No. 640.

Also make the following changes on plans No. 643 and No. 670: Change second sentence of first paragraph under Notes to read:

"Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

Plans No. 651, No. 652, No. 653, No. 654, No. 655 and No. 656:

Change second sentence of first paragraph under Notes to read:

"Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

Plan No. 774:

Change fourth paragraph under Notes to read:

"All special length splice bar bolts for connecting adjoining rails shall be furnished with crossing. Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

Also change title to read: "A.R.E.A. Solid Manganese Steel Crossing" and add underneath this line: "with Interior Connecting Rails."

Revisions to Specifications for Switches, Frogs, Crossings and Guard Rails, as follows:

Change Section 33, reading: "Flangeways. The width of flangeways shall not be less than nor more than $\frac{1}{16}$ inch greater than the width specified, when measured on the level of gage line $\frac{5}{8}$ inch below tread surface. Flangeways shall not be less than $1\frac{7}{8}$ inch deep measured from top of the tread surface, unless otherwise specified."—to read:

"33. Gages and Flangeways.

"Track gage may be $\frac{1}{8}$ inch under or $\frac{1}{16}$ inch over that specified for manganese construction and $\frac{1}{16}$ inch under or over for bolted construction.

"Guard gage (distance between guards) shall not exceed that specified but may be $\frac{1}{8}$ inch less.

"The width of flangeways may not be less than specified nor more than $\frac{1}{16}$ inch wider than specified.

"All the above measured on the level of gage line $\frac{5}{8}$ inch below tread surface.

"Flangeways shall not be less than $1\frac{7}{8}$ inch deep measured from top of tread surfaces, unless otherwise specified."

Change Section 47, reading: "The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery, and such defective material shall be replaced by the manufacturer at his own expense"—to read:

"47. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery.

"No guarantee of specific length of service will be required. A claim for defective material and/or workmanship shall cover only such defects as will impair the life of the work.

"No claim for free replacement of defective material and/or workmanship shall be recognized unless made promptly and based on defects appearing within three months from date of installation and in any event within two years from date of shipment."

Revision to Section 33 is recommended as above for reason that present specifications do not give tolerances for gage of track. The Committee considers such tolerances necessary, particularly for crossings.

Revision to Section 47 is recommended as above to clarify and amplify specifications in this respect in line with present practice.

Withdraw Index Pages I, II and III, dated March, 1927, and substitute Index Pages I, II, III and IV, dated March, 1928. Revised Index Page IV lists changes in plans that are offered for adoption or as information March, 1928, also changes in plans and specifications made since their last presentation, including changes recommended above.

Appendix B

(2) REPORT ON MATTER NOW APPEARING IN THE MANUAL RELATING TO CURVE ELEVATION, CANVASSING VARIOUS RAILROADS WITH VIEW OF ASCERTAINING THEIR PRACTICES AND VIEWS AND RECOMMEND SUCH CHANGES AS ARE FOUND DESIRABLE

C. W. Breed, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, J. B. Akers, W. G. Arn, W. H. Bevan, H. W. Brown, H. G. Clark, C. J. Geyer, F. S. Hales, E. T. Howson, T. T. Irving, E. R. Lewis, C. M. McVay, J. B. Myers, J. R. Watt.

This subject is still under investigation and we only have progress to offer.

Conclusions

The Committee recommends that the subject be continued.

Appendix C

(3) DETAILED PLANS OF SWITCHES, FROGS, CROSSINGS AND DOUBLE SLIP SWITCHES, INCLUDING SELF-GUARDED FROGS

C. R. Harding, Chairman, Sub-Committee; J. V. Neubert, E. W. Caruthers, J. W. DeMoyer, L. W. Deslauriers, E. B. Entwistle, O. F. Harting, F. H. Masters, J. C. Mock, A. J. Neafie, G. A. Peabody, W. H. Petersen, O. C. Rehfuss, I. H. Schram, G. J. Slibeck, G. M. Strachan, J. B. Strong, J. de N. Macomb.

The plans presented in this Appendix and the revisions to the Manual in Appendix A coming under this subject have been prepared in conference with the Standardization Committee of the Manganese Track Society.

ITEM I—SOLID MANGANESE CROSSINGS, STEAM RAILROAD OVER STEAM RAILROAD

Two years ago the Committee presented, as information to invite criticism, Plan No. 775 of Solid Manganese Steel Crossing, Single Rail Construction, angles 14 deg. 15 min. to 8 deg. 10 min., inclusive, dated December, 1925.

This plan, dated Revised November, 1927, with title changed to read: "A.R.E.A. Solid Manganese Steel Crossing, with Interior Connecting Rails," etc., is now offered for adoption as recommended practice, revised in other respects as to flangeway widths, lengths of guards and wording of notes.

This plan completes series of plans of solid manganese crossings, steam railroad over steam railroad.

ITEM II—MOVABLE POINT CROSSINGS

Plan No. 955, dated November, 1927, A.R.E.A. Details of Solid Manganese Steel Knuckle Rail for No. 8 and No. 10 Slip Switches, is offered for adoption as recommended practice.

Plans No. 801 to 804, inclusive, and No. 851 to No. 854, inclusive, detail only open-hearth construction for knuckle rails. Last year Plan No. 954, details of manganese railbound knuckle rail, was adopted as an alternate design. Plan No. 955, Details of Solid Manganese Steel Knuckle Rail, is offered for adoption as an additional alternate design.

The Committee has under consideration the preparation of a series of plans to cover movable point crossings of all angles and expects to make a report on this subject later.

ITEM III—FLANGE OR SELF-GUARDED FROGS

Plan No. 343, dated November, 1927, of A.R.E.A. No. 8 Self-Guarded Rigid Bolted Frog, is presented as information to invite criticism.

This plan gives dimensions for laying out No. 8 frogs of this type for all standard sections of rail of 80-lb. weight and over.

The Committee has under consideration the preparation of a series of plans of open-hearth self-guarded frogs to cover other frog numbers and expects to make a further report on this subject later.

ITEM IV—RAIL BOUND MANGANESE STEEL FROGS

The Committee offers for adoption as recommended practice the following plans of rail bound manganese steel frogs:

Plan No. 600, dated November, 1927, of A.R.E.A. rules for laying out rail bound manganese steel frogs (copied from Manual).

This plan conforms to rules for laying out rail bound manganese frogs in the 1921 Manual, pages 221 to 225, inclusive.

Plan No. 609, dated November, 1927, A.R.E.A. Nos. 9, 12 and 14 rail bound manganese steel frogs.

Plan No. 610, dated November, 1927, A.R.E.A. Nos. 15 and 18 rail bound manganese steel frogs.

Present plans Nos. 601 to 608, inclusive, of rail bound manganese steel frogs do not show details for frog numbers 9, 12, 14, 15, and 18, Design A and 18 Design B. Plans No. 609 and 610 have been prepared to cover these numbers and make the series of plans for rail bound manganese frogs more complete. In order to confine these additional frog numbers to two plans, sections are omitted but are covered by reference to existing plans.

Conclusions

The Committee recommends that the following plans submitted herewith be adopted as recommended practice and printed in the Manual.

Plan No. 775, dated (revised) November, 1927, solid managanese crossing.

Plan No. 955, dated November, 1927, details solid manganese knuckle rail for Nos. 8 and 10 slip switches.

Plan No. 600, dated November, 1927, rules for laying out rail bound manganese frogs.

Plan No. 609, dated November, 1927, Nos. 9, 12 and 14 rail bound manganese frogs.

Plan No. 610, dated November, 1927, Nos. 15 and 18 rail bound manganese frogs.

The Committee also recommends that the following plan submitted herewith be received as information:

Plan No. 343, dated November, 1927, No. 8 self-guarded rigid bolted frog.

Appendix D

(4) TRACK CONSTRUCTION IN PAVED STREETS

E. W. Caruthers, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, J. B. Akers, J. W. DeMoyer, J. E. Deckert, E. B. Entwistle, W. J. Harris, G. A. Peabody, O. C. Rehfuss, G. M. Strachan, J. B. Strong, J. de N. Macomb.

The plans presented in this Appendix and the revisions to the Manual in Appendix A coming under this subject have been prepared in conference with the Standardization Committee of the Manganese Track Society.

The Committee presents for adoption as recommended practice a series of plans of iron bound manganese center frogs for 7 inch and 9 inch girder rails, as follows:

Plan No. 984, dated November, 1927, A.R.E.A. Nos. 4 and 5 frogs, iron bound manganese steel center for 7 inch and 9 inch girder rails.

Plan No. 985, dated November, 1927, A.R.E.A. Nos. 6 and 8 frogs, iron bound manganese steel center for 7 inch and 9 inch girder rails.

Plan No. 986, dated November, 1927, A.R.E.A. No. 10 frog, iron bound manganese steel center for 7 inch and 9 inch girder rails.

The Committee has under consideration plans for grooved tongue switch and mate for industrial tracks and connected tongue switch for main line use for presentation at a later date.

Plans for iron bound manganese insert crossings are also under consideration for presentation in a report at a later date.

Conclusions

The Committee recommends that the following plans submitted herewith be adopted as recommended practice and printed in the Manual.

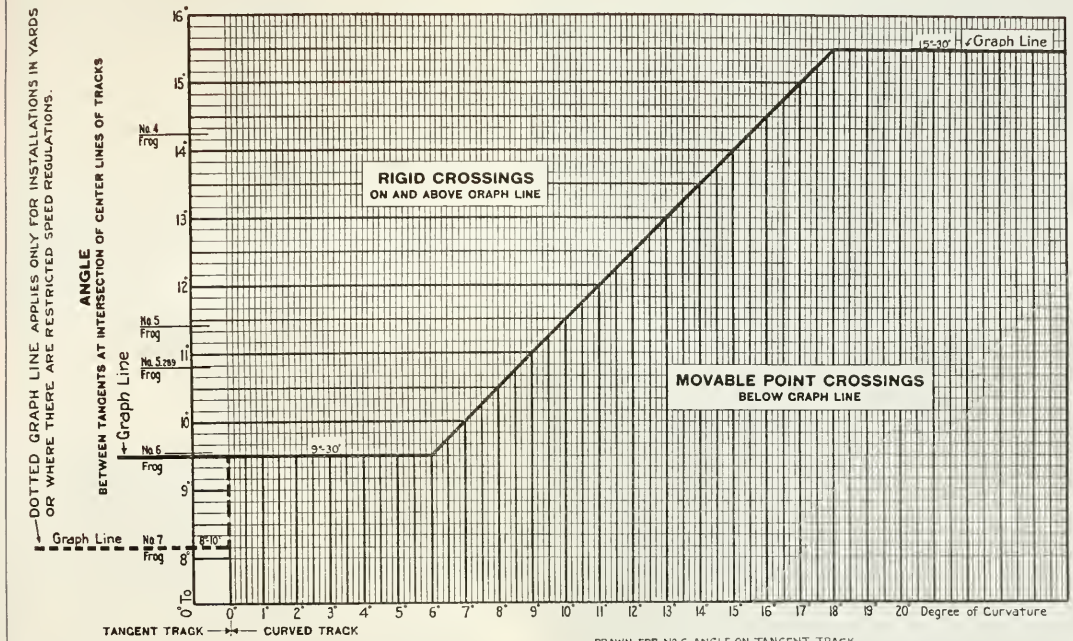
Plan No. 984, dated November, 1927, No. 4 and No. 5 iron bound manganese steel center frogs for 7 inch and 9 inch girder rails.

Plan No. 985, dated November, 1927, No. 6 and No. 8 iron bound manganese steel center frogs for 7 inch and 9 inch girder rails.

Plan No. 986, dated November, 1927, No. 10 iron bound manganese steel center frogs for 7 inch and 9 inch girder rails.

THIS DIMENSION TO BE 5' AS SHOWN ON
PLANS No 95 AND 352 TO APPLY FOR
No 6 TO No 7 ...

FOR
FOR S



GRAPH

THIS GRAPH SHOWS MINIMUM ANGLES BETWEEN TANGENTS AT INTERSECTION OF CENTER LINES OF TRACKS FOR WHICH RIGID POINT CROSSINGS MAY BE USED AS RECOMMENDED ON PLAN NO. 700, REVISED NOVEMBER, 1926.

FOR CURVED TRACK THE CENTER LINE OF TRACK HAVING THE GREATER DEGREE OF CURVATURE WITHIN THE LIMITS OF THE DIAMOND OF THE CROSSING SHALL APPLY

NOTES

TOE ENDS OF END FROGS SHALL BE EXTENDED TO CONNECT DIRECT WITH MOVABLE POINT RAILS WHEN CROSSING ANGLE AND DETAIL DOES NOT PERMIT SEPARATE CONNECTING RAILS OF 10 FT. IN LENGTH OR OVER.

RAIL BOUND MANGANESE STEEL KNUCKLE RAILS

Design A

Gage line lengths of manganese knuckle rail casting for angles 8°-10' (No. 7) and to but not including 11°-25' shall be es shown on plan No. 952.

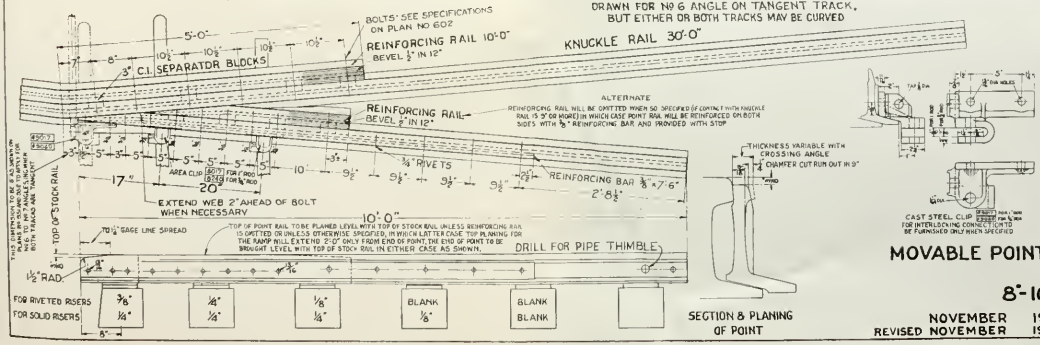
For angles 11°-25' (No. 5) and to but not including 15°-30' these lengths shall be 2' 7" from knuckle vertex.

SOLID MANGANESE STEEL KNUCKLE RAILS

Designs B and C

Gage line lengths of manganese knuckle rail casting for angles 8°-10' (No. 7) and to but not including 15°-30' shall be the same as shown on plan No. 952.

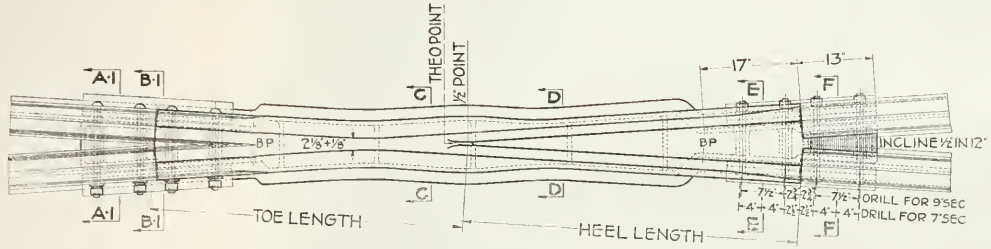
FOR FURTHER DETAILS NOT COVERED BY THIS PLAN, SEE PLANS NOS. 951 AND 952 OF NO. 7 MOVABLE POINT CROSSING, WHICH APPLY EXCEPT LENGTH OF PLATES SHALL BE INCREASED TO SUIT CROSSING ANGLE AND DETAIL.



A.R.E.A.
DETAILS OF
MOVABLE POINTS FOR CURVED CROSSINGS
ANGLES
8°-10' TO 15°-30' INC

NOVEMBER 1926
REVISED NOVEMBER 1927

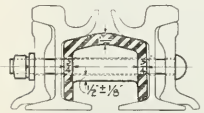
PLAN NO. 953

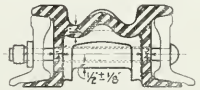


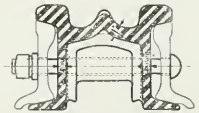
ARM LENGTHS						
FROG NUMBER	FROG ANGLE	HEEL LENGTH	HEEL SPREAD	TOE LENGTH	TOE SPREAD	TOTAL LENGTH
4	14°15'00"	3'-0"	0'-9⅞"	2'-4"	0'-6⅞"	5'-4"
5	11°25'16"	3'-6"	0'-8⅞"	2'-11"	0'-6⅞"	6'-5"
6	9°31'38"	3'-10"	0'-8⅛"	3'-6"	0'-6½"	7'-4"
8	7°09'10"	4'-10"	0'-7¾"	4'-7"	0'-6⅛"	9'-5"
10	5°43'29"	6'-1"	0'-7⅛"	5'-9"	0'-6⅛"	11'-10"

ALL SPECIAL LENGTH SPLICE BAR BOLTS FOR CONNECTING ADJOINING RAILS TO BE FURNISHED WITH FROG
BOLTS TO HAVE BUTTON HEADS, OVAL NECKS, SQUARE NUTS, AND SPRING WASHERS, UNLESS OTHERWISE SPECIFIED OR REQUIRED
SPLICE BARS NOT TO BE FURNISHED WITH FROG UNLESS SPECIFIED OR WHEN SPECIAL BARS ARE REQUIRED
ONE OR MORE PLUG INSERTS, OF IRON OR SOFT STEEL, TO ALLOW FOR DRILLING OF ELECTRICAL BOND HOLES, TO BE CAST IN VERTICAL WALLS, AS INDICATED BY 'B P' ON DRAWING, WHEN SO SPECIFIED
BOLT HOLES THROUGH CASTING TO BE ¼" LARGER THAN BOLT DIAMETER
TIE PLATES SHOULD BE USED WHEN SO SPECIFIED
¾"x8" TIE PLATES OF A MEDIUM GRADE OF COMMERCIAL MILD STEEL SHALL BE FURNISHED WITH FROG TO SUIT TIE LAYOUT
FOR PLAIN GIRDER OR TEE RAIL CONSTRUCTION
SEE PLAN 670, REVISED NOV. 1926

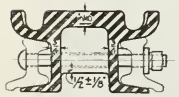
SECTION A-1-A-1
7" HIGH

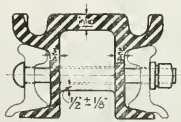

SECTION A-1-A-1
9" HIGH

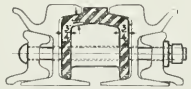

SECTION B-1-B-1
7" HIGH

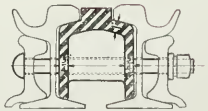

SECTION B-1-B-1
9" HIGH

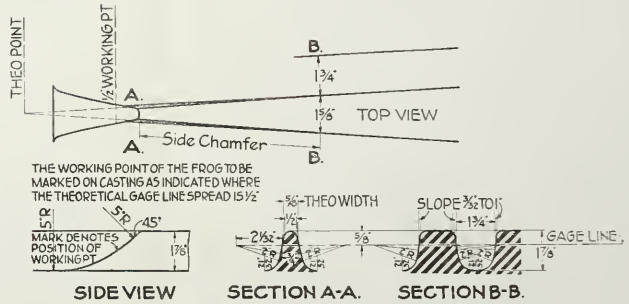
SECTION C-C
SECTION D-D


SECTION E-E
7" HIGH


SECTION E-E
9" HIGH


SECTION F-F
7" HIGH


SECTION F-F
9" HIGH



DETAIL OF POINT AND FLANGEWAY

A.R.E.A.
SOLID MANGANESE STEEL FROGS
FOR 7" AND 9" GIRDER RAILS

NOVEMBER 1926
REVISED, NOVEMBER 1927

PLAN Nº 983

A. R. E. A. INDEX

March, 1928

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
		Switches	
		Split Switches, Layouts	
101	Sep. 15, 1919	16′ 6″ Split Switch with Uniform Risers	Adopted Mar., 1920
102	Sep. 15, 1919	16′ 6″ Split Switch with Graduated Risers	Adopted Mar., 1920
103	Sep. 15, 1919	11′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
104	Sep. 15, 1919	11′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
105	Sep. 15, 1919	22′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
106	Sep. 15, 1919	22′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
107	Sep. 15, 1919	30′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
108	Sep. 15, 1919	30′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
		Diagrams of Preferred Names of Parts	
190	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Split Switches with Uniform Risers	Adopted Mar., 1921
191	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Split Switches with Graduated Risers	Adopted Mar., 1921
		Split Switch Fixtures	
201	Sep. 15, 1919	Details of Split Switch Fixtures (General)	Adopted Mar., 1920
202	Sep. 15, 1919	Details of Split Switch Fixtures (Special Features)	Adopted Mar., 1920
203	Sep. 15, 1919	Details of Split Switch Fixtures (Heel Plates and Turnout Plates)	Adopted Mar., 1920
204	Sep. 15, 1919	Details of Split Switch Fixtures (Heel Plates and Turnout Plates for 22′ 0″ and 30′ 0″ Switches)	Adopted Mar., 1920
205	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (General)	Adopted Mar., 1924
206	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Special Features)	Adopted Mar., 1924
207	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Heel Plates and Turnout Plates for 11′ 0″ and 16′ 6″ Switches)	Adopted Mar., 1924
208	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Heel Plates and Turnout Plates for 22′ 0″ and 30′ 0″ Switches)	Adopted Mar., 1924
		Illustration Bills of Material	
210	Sep. 15, 1919	Illustration Bills of Material for 11′ 0″ and 16′ 6″ Split Switches	Adopted Mar., 1920
211	Sep. 15, 1919	Illustration Bills of Material for 22′ 0″ and 30′ 0″ Split Switches	Adopted Mar., 1920
212	Nov., 1923	Illustration Bills of Material for Rails 6½″ High and Over for 11′ 0″ and 16′ 6″ Split Switches	Adopted Mar., 1924
		Derail Switch Point	
213	Nov., 1925	Details for Split Switch Point Derail	Adopted Mar. 1926
		Switch Stands	
251	Nov.17, 1920	Switch Stand Connecting Rods *and* Requisites for Switch Stands, including Connecting Rods	Adopted Mar., 1921
252	Nov., 1921	Detail of Lamp Tips for Switch Stands	Adopted Mar., 1922
253	Nov., 1922	Detail of Switch Stand Target Shapes	Adopted Mar., 1923
254	Nov., 1921	Day Target Discs for Switch Lamps	Adopted Mar., 1922
		Frogs	
		Bolted Rigid Frogs	
301	Sep. 15, 1919	No. 6 Bolted Rigid Frog	Adopted Mar., 1920
302	Sep. 15, 1919	No. 7 Bolted Rigid Frog	Adopted Mar., 1920
303	Sep. 15, 1919	No. 8 Bolted Rigid Frog	Adopted Mar., 1920
304	Sep. 15, 1919	No. 10 Bolted Rigid Frog	Adopted Mar., 1920
305	Sep. 15, 1919	Detail of Plates for No. 6, 7, 8 and 10 Bolted Rigid Frogs	Adopted Mar., 1920
306	Sep. 15, 1919	No. 11 Bolted Rigid Frog	Adopted Mar., 1920
307	Sep. 15, 1919	No. 16 Bolted Rigid Frog	Adopted Mar., 1920
308	Sep. 15, 1919	Detail of Plates for No. 11, 16 and 20 Bolted Rigid Frogs	Adopted Mar., 1920
309	Oct. 19, 1920	No. 4 and No. 5 Bolted Rigid Frogs	*Inform. Mar., 1921
320	Nov., 1920	Data for Laying Out Bolted Rigid Frogs	Adopted Mar., 1921
321	Nov., 1925	Tie Layout Standard Length Rigid Frogs for One-piece Guard Rail, 6 Ties, 19″ to 20″ Spacing, Suspended Joints	*Inform. Mar., 1926
325	Nov., 1925	Frog Fillers for Rails 80 lb. per Yard and Heavier	*Inform. Mar., 1926
		Clamp Frogs	
331	Sep. 15, 1919	No. 6 Clamp Frog	Adopted Mar., 1921
332	Sep. 15, 1919	No. 7 Clamp Frog	Adopted Mar., 1921
333	Sep. 15, 1919	No. 8 Clamp Frog	Adopted Mar., 1921
334	Sep. 15, 1919	No. 10 Clamp Frog	Adopted Mar., 1921
335	Sep. 15, 1919	Detail of Plates for No. 6, 7, 8 and 10 Clamp Frogs	Adopted Mar., 1921
		Bolted Rigid Self-Guarded Frogs	
343	Nov., 1927	No. 8 Rigid Bolted Self-Guarded Frog	*Inform. Mar., 1928
		Diagrams of Preferred Names of Parts	
390	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Bolted Rigid Frogs	Adopted Mar., 1921
391	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Clamp Frogs	Adopted Mar., 1921
		Spring Rail Frogs	
401	Sep. 15, 1919	No. 10 Spring Rail Frog	Adopted Mar., 1920
402	Sep. 15, 1919	No. 8 Spring Rail Frog	Adopted Mar., 1920
403	Sep. 15, 1919	No. 11 Spring Rail Frog	Adopted Mar., 1920
404	Nov., 1923	No. 10 Spring Rail Frog for Rails 6½″ High and Over	Adopted Mar., 1924
420	Nov., 1922	Data for Laying Out Spring Rail Frogs	Adopted Mar., 1923
490	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Spring Rail Frogs	Adopted Mar., 1921
		Guard Rails	
501	Nov., 1920	Details of Guard Rails	Adopted Mar., 1921
502	Nov., 1920	Details of Guard Rail Fixtures	Adopted Mar., 1921
590	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Guard Rails	Adopted Mar., 1921

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association.
The double star (**) indicates plan recommended to be adopted Mar., 1928.

A. R. E. A. INDEX

March, 1928

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
		Frogs, Manganese	
		Rail Bound Manganese Steel Frogs	
600	Nov., 1927	Data for Laying Out Rail Bound Manganese Steel Frogs	**Adopted Mar., 1928
601	Sep. 15, 1919	No. 6 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
602	Sep. 15, 1919	No. 7 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
603	Sep. 15, 1919	No. 8 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
604	Sep. 15, 1919	No. 10 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
605	Sep. 15, 1919	No. 11 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
606	Sep. 15, 1919	No. 16 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
607	Sep. 15, 1919	No. 20 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
608	Oct. 19, 1920	No. 4 and No. 5 Rail Bound Manganese Steel Frogs	*Inform. Mar., 1921
609	Nov., 1927	Nos. 9, 12 and 14 Rail Bound Manganese Steel Frogs	**Adopted Mar., 1928
610	Nov., 1927	Nos. 15 and 18 Rail Bound Manganese Steel Frogs	**Adopted Mar., 1928
		Solid Manganese Steel Self-Guarded Frogs	
640	Nov., 1926	Standard Dimensions for Solid Manganese Steel Self-Guarded Frogs	Adopted Mar., 1927
643	Nov., 1926	No. 8 Self-Guarded Frog, Solid Manganese Steel	Adopted Mar., 1927
		Solid Manganese Steel Frogs	
651	Sep. 15, 1919	No. 6 Solid Manganese Steel Frog	Adopted Mar., 1920
652	Sep. 15, 1919	No. 7 Solid Manganese Steel Frog	Adopted Mar., 1920
653	Sep. 15, 1919	No. 8 Solid Manganese Steel Frog	Adopted Mar., 1920
654	Sep 15, 1919	No. 10 Solid Manganese Steel Frog	Adopted Mar., 1920
655	Sep. 15, 1919	No. 11 Solid Manganese Steel Frog	Adopted Mar., 1920
656	Oct. 19, 1920	No. 4 and No. 5 Solid Manganese Steel Frogs	*Inform. Mar., 1921
670	Nov., 1926	Standard Dimensions for Solid Manganese Steel Frogs	Adopted Mar., 1927
		Diagrams of Preferred Names of Parts	
690	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Rail Bound Manganese Steel Frogs	Adopted Mar., 1921
691	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Solid Manganese Steel Frogs	Adopted Mar., 1921
		Crossings	
700	Nov., 1926	Application of Crossing Designs and Recommended Practices	Adopted Mar., 1927
700-A		Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-A	Example No. 1	Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-A	Example No. 2	Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-B	Nov., 1924	Data and Record Sheet for Ordering Compromise Joints	Adopted Mar., 1925
700-C	Nov., 1924	Data and Record Sheet for Ordering Compromise Rails	Adopted Mar., 1925
		Bolted Rail Crossings	
701	Oct., 1921	Three Rail Design—Angles 90° to 50°, inclusive	Adopted Mar., 1922
702	Oct., 1921	Two Rail Design—Angles 90° to 50°, inclusive	Adopted Mar., 1922
703	Oct., 1921	Three Rail Design—Angles below 50° to 35°, inclusive	Adopted Mar., 1922
704	Oct., 1921	Two Rail Design—Angles below 50° to 35°, inclusive	Adopted Mar., 1922
705	Oct., 1921	Three Rail Design—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
706	Oct., 1921	Two Rail Design—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
707	Oct., 1921	Single Rail Design and Two Rail Design with Short Easer Rails—Angles below 25° and above 14° 15′	Adopted Mar., 1922
708	Oct., 1921	Single Rail Design and Two Rail Design—Angles below 25° and above 14° 15′	Adopted Mar., 1922
709	Oct., 1921	Single Rail Design and Two Rail Design with Short Easer Rails—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
710	Oct., 1921	Single Rail Design and Two Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
		Bolted Rail Crossings, Electric Railway over Steam Railroad	
716	Nov., 1924	Bolted Rail Crossings, Steam Railroad over Electric Railway—Angles 90° to 50°, inclusive	Adopted Mar., 1925
717	Nov., 1924	Bolted Rail Crossings, Steam Railroad over Electric Railway—Angles below 50° to 30°, inclusive	Adopted Mar., 1925
		Tie Layouts for Railroad Crossings	
719-A	Nov., 1927	Tie Layout for Railroad Crossings, angles 8° 10′ to 14° 15′	*Inform. Mar., 1928
719-B	Nov., 1927	Tie Layout for Railroad Crossings, angles 14° 15′ to 25°	*Inform. Mar., 1928
719-C	Nov., 1927	Tie Layout for Railroad Crossings, angles 25° to 50°	*Inform. Mar., 1928
720	Dec., 1925	Tie Layout for Railroad Crossings, Angles 50° to 90°	*Inform. Mar., 1926
720-A	Nov., 1926	Alternate Tie Layouts for Railroad Crossings, angles up to 90°	*Inform. Mar., 1927
		Reinforced Concrete and Pile Crossing Foundations	
721	Nov., 1927	Design of Reinforced Concrete and Pile Crossing Foundations	**Adopted Mar., 1928
		Manganese Steel Insert Crossings	
751	Nov., 1920	Designs and Dimensions of Inserts, Detail A—Angles 45° to above 14° 15′	Adopted Mar., 1922
752	Nov., 1920	Designs and Dimensions of Inserts, Detail B—Angles 45° to above 14° 15′	Adopted Mar., 1922
753	Nov., 1920	Designs and Dimensions of Inserts—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
754	Oct., 1921	Three Rail Design, Detail A—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
755	Oct., 1921	Two Rail Design, Detail A—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
756	Oct., 1921	Three Rail Design, Detail A—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
757	Oct., 1921	Two Rail Design, Detail A—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
758	Oct., 1921	Two Rail Design with Short Easer Rails, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
759	Oct., 1921	Two Rail Design, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
760	Oct., 1921	Single Rail Design with Short Easer Rails, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
761	Oct., 1921	Single Rail Design, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
762	Oct., 1921	Three Rail Design, Detail B—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
763	Oct., 1921	Three Rail Design, Detail B—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
764	Oct., 1921	Two Rail Design with Short Easer Rails, Detail B—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
765	Oct., 1921	Two Rail Design with Short Easer Rails, Detail B—Angles below 25° and above 14° 15′	Adopted Mar., 1922
766	Oct., 1921	Single Rail Design with Short Easer Rails, Detail B—Angles below 25° and above 14° 15′	Adopted Mar., 1922
767	Oct., 1921	Two Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
768	Oct., 1921	Single Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
		Manganese Steel Insert Crossings, Electric Railway over Steam Railroad	
778	Nov., 1925	Manganese Steel Insert Crossings, Steam Railroad over Electric Railway, Angles below 45° to 30° inclusive	Adopted Mar., 1926
		Insulated Internal Joints	
770	Nov., 1922	Insulated Internal Joint for Crossings, Three Rail Design—Angle below 45° to 25°, inclusive	*Inform. Mar., 1923

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The double star (**) indicates plan recommended to be adopted Mar., 1928

A. R. E. A. INDEX

March, 1928

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
		Solid Manganese Crossings	
771	Nov., 1923	Solid Manganese Steel Crossings—Angles 90° to 60°, inclusive.	Adopted Mar. 1924
771-B	Nov., 1924	Solid Manganese Steel Crossings—Angles 90° to 60°, inclusive, Design No. 2 and Design No. 3, Alternates for Design detailed on Plan 771	*Inform. Mar., 1925
772	Nov., 1923	Solid Manganese Steel Crossings—Angles below 60° to 40°, inclusive	Adopted Mar., 1924
773	Nov., 1924	Solid Manganese Steel Crossings—Angles below 40° to 25°, inclusive	Adopted Mar., 1925
774	Nov., 1926	Solid Manganese Steel Crossing with interior connecting rails. Double Rail Construction—Angles below 25° and above 14° 15′	Adopted Mar., 1927
775	Nov., 1927	Solid Manganese Steel Crossing, with Interior Connecting Rails, Single Rail Construction angles, 14° 15′ to 8° 10′, incl.	**Adopted Mar., 1928
		Solid Manganese Crossings, Electric Railway over Steam Railroad	
776	Nov., 1923	Solid Manganese Steel Crossings, Steam Railroad over Electric Railway—Angles 90° to 60°, inclusive	Adopted Mar., 1924
777	Nov., 1923	Solid Manganese Steel Crossings, Steam Railroad over Electric Railway—Angles below 60° to 40°, inclusive	Adopted Mar., 1924
780	Nov., 1926	Solid Manganese Steel Crossings, steam railroad over electric railway, for 7″ and 9″ girder rails, angles 90° to 60°, inclusive	Adopted Mar., 1927
781	Nov., 1926	Solid Manganese Steel Crossings, steam railroad over electric railway, for 7″ and 9″ girder rails, angles below 60° to 40°, inclusive	Adopted Mar., 1927
		Tables for Gages and Flangeways	
791	Nov., 1921	*Table No.* 1—Gages and Flangeways in Curved Track	Adopted Mar., 1922
792	Nov., 1921	*Table No.* 2—Gages and Flangeways in Curved Track—Gage Diagrams for Rigid Wheel Base Locomotives	Adopted Mar., 1922

Double Slip Switches

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
		Double Slip Switch Layouts	
801	Nov., 1922	No. 8 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1923
802	Nov., 1922	No. 8 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1923
803	Nov., 1923	No. 10 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1924
804	Aug., 1923	No. 10 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1924
		Details of Double Slip Switches	
851	Nov., 1922	Details of No. 8 Double Slip Switch with Movable Center Points Uniform Risers	Adopted Mar., 1923
852	Nov., 1922	Details of No. 8 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1923
853	Nov., 1923	Details of No. 10 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1924
854	Aug., 1923	Details of No. 10 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1924

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
		Diagram of Preferred Names of Parts	
890	Nov., 1924	Diagram illustrating Preferred Names of Parts of Double Slip Switch with Movable Center Points	Adopted Mar., 1925

Turnouts and Crossovers

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
900	Nov., 1920	Table of Practical Turnout Leads *and* Table of Theoretical Turnout Leads	Adopted Mar., 1921
		Turnout and Crossover Layouts	
901	Sep. 20, 1920	Layout of No. 6 Turnout and Crossover	Adopted Mar., 1921
902	Sep. 20, 1920	Layout of No. 7 Turnout and Crossover	Adopted Mar., 1921
903	Sep. 20, 1920	Layout of No. 8 Turnout and Crossover with Rigid Frogs	Adopted Mar., 1921
904	Sep. 20, 1920	Layout of No. 8 Turnout and Crossover with Spring Frogs	Adopted Mar., 1921
905	Sep. 20, 1920	Layout of No. 10 Turnout and Crossover	Adopted Mar., 1921
906	Sep. 20, 1920	Layout of No. 11 Turnout and Crossover	Adopted Mar., 1921
907	Sep. 20, 1920	Layout of No. 16 Turnout and Crossover	Adopted Mar., 1921
908	Sep. 20, 1920	Layout of No. 20 Turnout and Crossover	Adopted Mar., 1921

Movable Point Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
951	Nov., 1926	Layout of No. 7 Movable Point Crossing	Adopted Mar., 1927
952	Nov., 1926	Details of Manganese Knuckle Rails and Details of Plates for No. 7 Movable Point Crossing	Adopted Mar., 1927
953	Nov., 1927	Details of Movable Points for Curved Crossings, angles 8° 10′ to 15° 30′ incl.	**Adopted Mar., 1928
954	Nov., 1926	Details of Manganese Rail Bound Knuckle Rails for No. 8 and No. 10 slip switches	Adopted Mar., 1927
955	Nov., 1927	Details of Solid Manganese Steel Knuckle Rail for No. 8 and No. 10 Slip Switches	**Adopted Mar., 1928

Track Construction for Paved Streets

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
980	Nov., 1926	Alinement details for turnouts, tongue switch construction, for use in paved streets	Adopted Mar., 1927
983	Nov., 1927	Solid Manganese Steel Frogs for 7″ and 9″ Girder Rails	**Adopted Mar., 1928
984	Nov., 1927	Nos. 4 and 5 Frogs, Iron Bound Manganese Steel Center, for 7″ and 9″ Girder Rails	**Adopted Mar., 1928
985	Nov., 1927	Nos. 6 and 8 Frogs, Iron Bound Manganese Steel Center, for 7″ and 9″ Girder Rails	**Adopted Mar., 1928
986	Nov., 1927	No. 10 Frog, Iron Bound Manganese Steel Center, for 7″ and 9″ Girder Rails	**Adopted Mar., 1928

Specifications and Definitions

Appendix A	Specifications for the Design and Dimensions of Manganese Steel Pointed Switches	Adopted Mar., 1920
Appendix B	Specifications for Switches, Frogs, Crossings and Guard Rails	Adopted Mar., 1921
Appendix C	Definitions of Switch, Frog, Guard Rail, Crossing and Turnout Terms	Adopted Mar., 1924

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A. R. E. A. INDEX—SUPPLEMENT

March, 1928

Changes in Plans and Specifications listed in 1928 Index (Pages I, II and III) made since their last presentation.

Revisions to All Plans and Specifications

All future plans and specifications to have initials "A.R.E.A." that is, abbreviation for American Railway Engineering Association, placed thereon in a conspicuous manner, preferably above main title. Existing plans and specifications are to be modified in this respect only when reprinted.

Revisions to Plans Since Last Presentation

(This list includes revisions offered March, 1927, and March, 1928)

Nos. 301, 302, 303, 304, 306, 307, 309, 331, 332, 333, 334, 401, 402, 403, 404 and 501:

Omit physical test specifications for heat treated bolts, as these requirements are covered by Section 14, Specifications Appendix B, which supersede same.

Nos. 305 and 308:

Add the following note: "For tie layouts to accommodate one-piece guard rails requiring five tie spaces from 19 in. to 20 in., see Plan No. 321."

Also make the following change on these two plans: In section showing clip for fastening base plate change diameter of clip bolt from $\frac{7}{8}$ in. to $\frac{3}{4}$ in.

No. 608:

In detail of heel rail change spread between gage lines at beginning of flare in manganese from $2\frac{1}{4}$ in. to $1\frac{5}{8}$ in.

No. 640:

Omit Classes "H" and "J," as lengths given do not allow proper tie spacing.

Nos. 643 and 670:

Omit Classes "H" and "J," as lengths given do not allow proper tie spacing.

Also make the following change on these two plans: Change second sentence of first paragraph under Notes to read: "Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

Nos. 651, 652, 653, 654, 655 and 656:

Add the following note: "For heavy rail data and additional options, see Plan No. 670, dated November, 1926; also disregard tabulated heights and widths designated as 'Casting Data'."

Also change second sentence of first paragraph under Notes to read: "Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

No. 700-A:

Under "Compromise Joints" in middle of sheet, change caption of first column to read "No. of Joints" instead of "No. of Pairs."

On right half of plan there are listed nine items of data to be shown on diagram; add a tenth item reading as follows:

"Tie layout, if crossing is to have base or tie plates."

Nos. 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 716, 717, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 771, 772, 774, 775, 776, 777 and 778.

Add the following note:

"For Application of A.R.E.A. Crossing Designs and Recommended Practices, see Plan No. 700, dated November, 1926."

No. 771-B:

Add the following note: "For application of A.R.E.A. Crossing Designs and Recommended Practices, see Plan No. 700, dated November, 1926."

Also in type A joint, change $5\frac{1}{2}$ in. space to $6\frac{1}{2}$ in. and show splice bar 31 in. long. In type B joint, show splice bar 31 in. long.

Also change first sentence of Note 6 to read:

"All special length splice bar bolts for connecting adjoining rails to be furnished with crossing and to have square nuts and spring washers unless otherwise specified or required."

No. 773:

Add the following note: "For Application of A.R.E.A. Crossing Designs and Recommended Practices, see Plan No. 700, dated November, 1926."

Also change last paragraph of specifications relating to special length splice bar bolts to read: "All special length splice bar bolts for connecting adjoining rails shall be furnished with crossing, and to have square nuts and spring washers unless otherwise specified or required. Splice bars for connecting adjoining rails not to be furnished unless specified, or unless special bars are required."

No. 774:

Change title to read: "A.R.E.A. Solid Manganese Steel Crossing, with Interior Connecting Rails, Angles below 25° 00′ and above 14° 15′, Double Rail Construction."

Also change fourth paragraph under Notes to read:

"All special length splice bar bolts for connecting adjoining rails shall be furnished with crossing. Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

Nos. 851, 852, 853, 854:

Add the following note:

"Details shown on this plan apply to rails less than $6\frac{1}{2}$ in. high. For details for rails $6\frac{1}{2}$ in. and higher, see Plans No. 205 to 208, inclusive."

Revisions to Specifications for Switches, Frogs, Crossings and Guard Rails (Appendix B) Since Last Presentation

Change Section 33 to read:

"33. Gages and Flangeways.

"Track gage may be $\frac{1}{8}$″ under or $\frac{1}{16}$″ over that specified for managnese construction and $\frac{1}{16}$″ under or over for bolted construction.

"Guard gage (distance between guards) shall not exceed that specified but may be $\frac{1}{8}$″ less.

"The width of flangeways may not be less than $\frac{1}{16}$″ wider than specified.

"All the above measured on the level of gage line $\frac{5}{8}$″ below tread surface.

"Flangeways shall not be less than $1\frac{7}{8}$″ deep measured from top of tread surfaces, unless otherwise specified."

Change Section 47 to read:

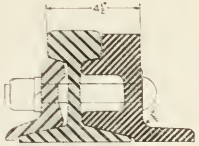
"47. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery.

"No guarantee of specific length of service will be required. A claim for defective material and/or workmanship shall cover only such defects as will impair the life of the work.

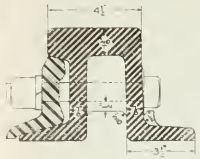
"No claim for free replacement of defective material and/or workmanship shall be recognized unless made promptly and based on defects appearing within three months from date of installation and in any event within two years from date of shipment."

NOTE: Plans listed in this index, Pages I, II, III and IV, have been designed for standard tee rails of sections down to and including 80 lb. per yard in weight and for girder rails as noted. They will not apply in all details for lighter section tee rails weighing less than 80 lb. per yard.

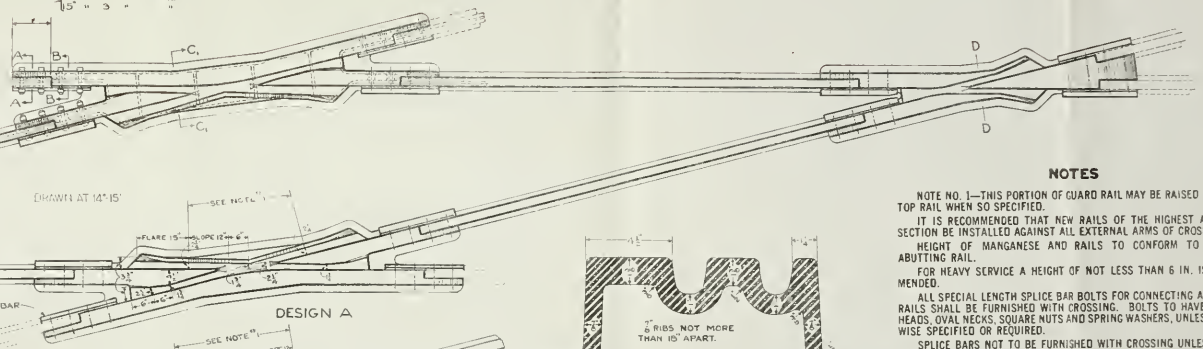
SECTION A-A
ALTERNATE

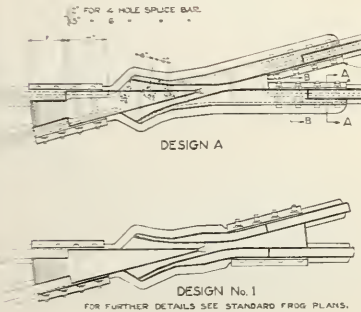


SECTION A-A

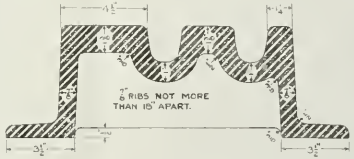


SECTION B-B

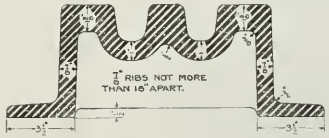




SECTION C_2-C_2



SECTION C_1-C_1



SECTION D-D

DESIGN No. 2.
FOR FURTHER DETAILS SEE STANDARD FROG PLANS.

TABLE OF ARM LENGTHS FROM THEORETICAL POINT

	END FROGS									CENTER FROGS			
	DESIGN A			DESIGN No. 1			DESIGN No. 2			DESIGN A		DESIGN B	
ANGLE	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	ARM LENGTHS	TOTAL LENGTH	ARM LENGTHS	TOTAL LENGTH
8°-10'	4'-0"									6'-7"	13'-2"	4'-0"	8'-0"
8°-48'	3'-9"									6'-2"	12'-4"	3'-9"	7'-6"
9°-32'	3'-6"									5'-9"	11'-6"	3'-6"	7'-0"
10°-23'	3'-3"	← FOR	THESE	LENGTHS	SEE	PLANS	651	652	0.656+	5'-4"	10'-8"	3'-3"	6'-6"
11°-25'	3'-0"									5'-0"	10'-0"	3'-0"	6'-0"
12°-41'	2'-9"									4'-7"	9'-2"	2'-9"	5'-6"
14°-15'	2'-6"									4'-2"	8'-4"	2'-6"	5'-0"

NOTE:- FOR INTERMEDIATE ANGLES USE LENGTHS SPECIFIED FOR NEXT SMALLER ANGLE.

NOTES

NOTE NO. 1—THIS PORTION OF GUARD RAIL MAY BE RAISED 1" ABOVE TOP RAIL WHEN SO SPECIFIED.

IT IS RECOMMENDED THAT NEW RAILS OF THE HIGHEST ABUTTING SECTION BE INSTALLED AGAINST ALL EXTERNAL ARMS OF CROSSING.

HEIGHT OF MANGANESE AND RAILS TO CONFORM TO HIGHEST ABUTTING RAIL.

FOR HEAVY SERVICE A HEIGHT OF NOT LESS THAN 6 IN. IS RECOMMENDED.

ALL SPECIAL LENGTH SPLICE BAR BOLTS FOR CONNECTING ADJOINING RAILS SHALL BE FURNISHED WITH CROSSING. BOLTS TO HAVE BUTTON HEADS, OVAL NECKS, SQUARE NUTS AND SPRING WASHERS, UNLESS OTHERWISE SPECIFIED OR REQUIRED.

SPLICE BARS NOT TO BE FURNISHED WITH CROSSING UNLESS SPECIFIED OR WHEN SPECIAL BARS ARE REQUIRED. MAXIMUM LENGTH OF SPLICE BARS TO BE USED, 30 INCHES.

BOLT HOLES THROUGH CASTING SHALL BE 1/4" LARGER THAN BOLT DIAMETER.

TIE PLATES SHOULD BE USED.

TIE PLATES WHEN SO SPECIFIED SHALL BE FURNISHED WITH CROSSING 3/4" X 8" ROLLED STEEL OF A MEDIUM GRADE OF COMMERCIAL MILD STEEL TO SUIT TIE LAYOUT; IN WHICH CASE TIE LAYOUT PLANS SHALL BE FURNISHED TO THE MANUFACTURER BY THE RAILROAD ACCOMPANYING ORDERS FOR CROSSINGS.

FOR APPLICATION OF A.R.E.A. CROSSING DESIGNS AND RECOMMENDED PRACTICES, SEE PLAN NO. 700.

POINTS OF CENTER FROGS SHALL CONFORM TO DETAILS SHOWN ON PLAN NO. 753.

A.R.E.A.
SOLID MANGANESE STEEL CROSSING

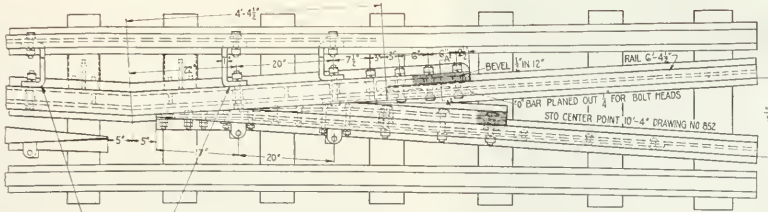
WITH INTERIOR CONNECTING RAILS

ANGLES 14°-15' TO 8°-10' INCL.
SINGLE RAIL CONSTRUCTION

DECEMBER, 1925
REVISED NOVEMBER, 1927

PLAN No. 775

28

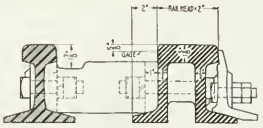


NO 8 SOLID MANGANESE STEEL KNUCKLE RAIL

SCALE

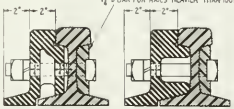
12" 9" 6" 3" 0" 1'-0"

NOTE
MANGANESE POINTS OF APPROVED DESIGN MAY BE USED WHEN SO SPECIFIED



SECTION AT POINT

1"×⅞" BAR FOR 100LB RAIL & LIGHTER
1¼"×⅞" BAR FOR RAILS HEAVIER THAN 100LB



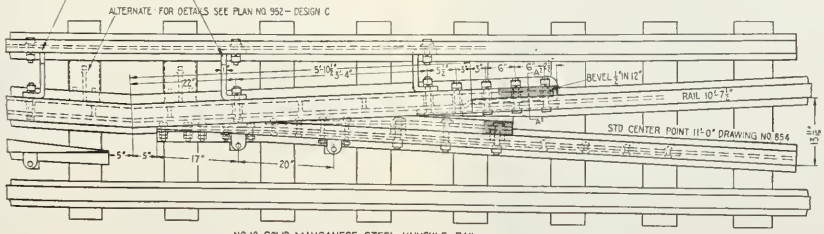
SECTION A²-A²

ALTERNATE

NOTE:
1⅜"DIA BOLTS FOR 120LB RAIL & HEAVIER.
1¼"DIA BOLTS FOR RAILS LESS THAN 120LBS & DOWN TO RAILS HAVING 3" FISHING HEIGHT.
1⅛"DIA BOLTS FOR RAILS HAVING LESS THAN 3" FISHING HEIGHT, DOWN TO & INCLUDING 80LB RAIL.

THESE SEPARATORS TO BE OMITTED WHEN USING CENTER BRACE CAST INTEGRAL WITH RAIL

ALTERNATE: FOR DETAILS SEE PLAN NO 952 – DESIGN C



NO 10 SOLID MANGANESE STEEL KNUCKLE RAIL

SCALE

12" 9" 6" 3" 0" 1'-0"

NOTE
MANGANESE POINTS OF APPROVED DESIGN MAY BE USED WHEN SO SPECIFIED

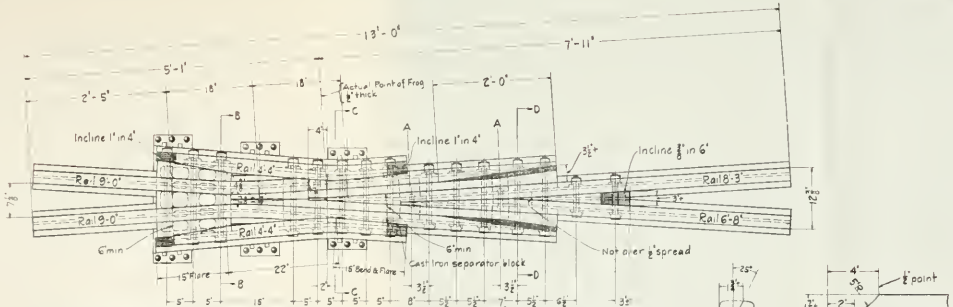
A.R.E.A.
DETAILS OF
SOLID MANGANESE STEEL KNUCKLE RAIL
FOR Nº8 & Nº10 SLIP SWITCHES

ALTERNATE DESIGN FOR OH CONSTRUCTION DETAILED ON PLANS 801 TO 804 INCLUSIVE AND PLANS 851 TO 854 INCLUSIVE

ALTERNATE DESIGN FOR MANGANESE RAILBOUND KNUCKLE RAIL PLAN Nº 954

NOVEMBER 1927

PLAN Nº 955



SPECIFICATIONS

BOLTS – Through bolts 1 1/8" dia. for 120 lb rail and heavier
3/4" dia bolts for rails less than 120 lb and down to rails having 3" fishing height
5/8" dia bolts for rails having less than 3" fishing height down to and including 80 lb rail
Fishing height shall be measured on vertical center line of rail.
All through bolts, including those in heel riser block, to be heat treated steel,
See Specifications, Appendix B
All through bolts to have extra thick nuts and tight fit except thru castings
Through bolts to have square heads and nuts with U.S. Standard thread fitted with head locks, nutlocks and barel washers where necessary to afford square bearing
Suitable washers in any case shall be placed under nuts to bring same out from under head of rail, so that they may be tightened with a standard wrench

FILLERS – Filler blocks shall fit the fishing angles and the web of rail for a distance of 3" from above and below the base and head respectively and shall maintain the required flangeway
Throat filler block, point separator blocks and taper and elevation blocks shall be of good quality cast iron
Body filler blocks shall be of rolled steel in one continuous length either single or double groove section, or of good quality grey cast iron when specified, in which case they shall be furnished of single groove section and in three lengths with open spaces A as indicated by dotted lines.

HEEL RISER – Heel riser shall be of steel rail, head up with flange upset to properly fit over and rest upon bases of adjoining rails or of other approved design that will insure a proper bearing on the bases of the heel rails and will provide rolled or forged steel wearing surface equal in hardness to rail steel

RIVETS – Rivets through point rails shall be 1/8" less in diameter than the through bolts. They may be countersunk.
If either button or cone head rivets are used, filler blocks must be cut out to clear

PLATES – When additional bearing plates are required they shall be as per Plan No 305

LENGTHS – Lengths of frogs overall shall not vary more than 1/4" from length specified. Frogs may be furnished to modified lengths to meet alignment of track or local conditions when specified

FOOT GUARDS – Additional foot guarding to that shown in plan view to be furnished when so specified

BEVELED ENDS OF WING RAILS – Flared end of wing rails may be beveled on an angle of 45° as per detail when so specified

A. R. E. A.
NO. 8 SELF GUARDED FROG
RIGID BOLTED TYPE

ANGLE 7°09'10"

NOVEMBER, 1927

PLAN NO. 343

RULES FOR LAYING OUT DESIGN A

Applicable to All Frogs from No. 4 to No. 20, Inclusive

1. Heel

The heel end of manganese point is placed where the spread between gage lines is $4\frac{1}{4}$ in

2. Heel Block Extension

The heel block extension running out from the heel of manganese point between the heel rails to be 2⅜ in. long for frogs Nos. 4, 5 and 6 and 3⅜ in. long for No. 7, above No. 7, the heel extension is to run on beyond the point where spread between gage lines is $7\frac{1}{4}$ in. The heel block extension is integral with the manganese body casting on all frogs up to and including No. 15; for frogs No. 16 to No. 20, inclusive, the integral part is made $10\frac{1}{2}$ in. long from the heel of manganese point and a separate heel block casting forms the balance. The rear at the end of all heel blocks is to have a slope from $\frac{1}{2}$ in. below the level of the head of rails at the end to tread level in a length of 6 in.

3. Heel Rails

The heel rails are offset horizontally toward the gage line by a short bend at the end of the heel block extension and a reverse bend 15 in. from the point end of the rails on all frogs up to and including No. 15 and 20½ in. from the point end of the rail for frogs No. 16 to No. 20 inclusive, so as to bring the center line of web $\frac{7}{8}$ in. (+ $\frac{1}{8}$ in.) from gage line of frog and running parallel to gage line from point end to reverse bend. Head on gage line is planed to straight line conforming to side contour of head. Back of head is planed to a straight taper with a vertical side from $1\frac{1}{2}$ in. net width of head at point to full section at end of heel block extension.

The point end of rail is cut at an angle of 45 deg. to the gage line and the back of head at point end is rounded by 5 in. radius.

4. Wing Rail

Wing rail laps heel rail from point end to reverse bend or for a length of $15\frac{1}{2}$ in. for all frogs up to and including No. 15, and 20½ in. for No. 16 to No. 20, inclusive, and is parallel to gage line with a width of flangeway of $2\frac{1}{4}$ in. using a standard section filler made for a $1\frac{1}{4}$ in. flangeway with full rail heads, but producing a width of $2\frac{1}{4}$ in. between the line of head of wing rail and the planed away head of heel rail. The side of the head of wing rail is planed for a straight flare on the guard side running on a line from the $13\frac{1}{4}$ in. width flangeway opposite to a $2\frac{1}{4}$ in. spread of the gage lines (except for No. 4 and No. 5 frogs to a $3\frac{1}{2}$ in. flare opening at the end of a flare measured $\frac{1}{4}$ in. below tread level. The side of flare planing on the wing rail commencing at the end of the manganese wing to be on a bevel of 25 deg. from vertical. For No. 4 and No. 5 frogs the beginning of the flare line is placed at opposite spread between gage line of $1\frac{5}{8}$ in. instead of $2\frac{1}{4}$ in.

Where the flare line intersects the side of the head of wing rail at the $2\frac{1}{4}$ in. width of flangeway measured $\frac{5}{8}$ in. below tread level, head of wing rail is notched to a radius of $\frac{5}{8}$ in. for the reception of the manganese steel wing and rail is bent outward on a straight line so as to bring side of full head 4 in. from gage line opposite theoretical point. Opposite theoretical point wing rail is bent back on a line running to a gage line toe spread of 3 in., but on an angle of not less than 1 in 8 with gage line (frogs No. 4 to No. 10, inclusive). If angle comes out smaller than 1 in 8, reduce toe spread (2.91 in. for No. 11 frog and 2.67 in. for No. 12 frog) to make the angle 1 in 8 until a minimum toe spread of $2\frac{1}{2}$ in. is reached (frogs No. 14 to No. 20, inclusive) when such minimum spread and minimum angle of 1 in 8 are kept and the middle bend of wing rail moved toward the toe end of the frog by extending the line of wing rail running from the notch to the point 4 in. out at theoretical point until such line meets the line drawn from $2\frac{1}{2}$ in. toe spread on the 1 in 8 angle. Head is planed with vertical side from notch to full section of head at middle bend.

5. Manganese Steel Body and Wings

From the heel end of the manganese point at the $4\frac{3}{4}$ in. spread the manganese is carried across the flangeway on an angle of 30 deg. to the gage line to the web of the wing rail. It then follows the web of bent wing rail to the bend at toe, where the manganese body ends. The back of the manganese wing fits into the notch in the wing rail and follows the planed and bent head of the wing rail to the toe end, where it lies up against the side of the full head section of the wing rail, the end being sloped and rounded. Manganese wing is flared to follow flare line from $13\frac{1}{4}$ in. width of flangeway to $2\frac{1}{4}$ in. opening at notch to meet flare planed in wing rail. Bottom bearing of the manganese steel casting on top of base of wing rail to be continuous throughout except at bends. Bearing under head and against web of wing rail to be 3 in. long at every other through bolt commencing with the second bolt from the manganese heel towards the toe down to the first bolt from the theoretical point towards the heel and then at every bolt to the toe end; and for a length of 4 in. at the last bolt through the toe end of manganese body.

Heel extension to have continuous bearing on the top of base of heel rails and to bear against the web and under head continuous from the point end of heel rails for same length as flangeway filler, then for 3 in. at each bolt beyond end of filler and 4 in. at end of heel block extension.

6. Fillers and Toe Blocks

Fillers between heel rails and wing rails are of a constant length of $14\frac{1}{4}$ in. for frogs No. 4 to No. 15, inclusive, and $19\frac{1}{4}$ in. for frogs No. 16 to No. 20, inclusive, measured on gage line, being cut on an angle of 30 deg. to correspond to angle of manganese steel body carried across flangeway and square on outer end, except when wing rails are beveled, when filler is cut flush with end of the same angle as the wing rail.

Toe blocks are placed 2 in. from the toe end of the manganese body and are 7 in. long, with one bolt for all frogs up to and including No. 15, and 12 in. long with two bolts for frogs No. 16 to No. 20, inclusive.

7. Bolt Spacing

At heel end spacing of bolts through heel rails, wing rails and fillers is constant; 3 in.-5 in.-5 in. for all frogs from No. 4 to No. 15, inclusive, and 3 in.-5 in.-5 in.-5 in. for frogs No. 16 to No. 20, inclusive, measured on gage line from point end of heel rail. Bolt at end of heel block extension is placed 2 in. from extreme end of all frogs. In 26 in. long heel block extension one additional bolt is placed midway between end bolt and last bolt through filler (No. 7 and No. 8 frogs). In longer extensions (No. 9 frog and above) first bolt outside of end of wing rails is placed $6\frac{1}{2}$ in. from last bolt through flangeway fillers and additional bolts (No. 11 frog and above) are spaced between this bolt and the end bolt in least number of equal spaces not exceeding 10 in. from c. to c. At toe end position of bolts through toe block is constant, being 6 in. measured on gage line from toe end of manganese body for 7 in. toe block and 4 in.-8 in. for 12 in. toe block. Position of first two bolts through manganese body at toe end is constant 2 in.-7 in. for all frogs, measured on gage line from toe end of casting. Body bolts between fixed position of bolts at heel and toe ends are spaced in least number of equal spaces not exceeding 12 in. from c. to c.

RULES FOR LAYING OUT DESIGN B

Applicable to All Frogs from No. 16 to No. 20, Inclusive

The rules for the laying out of Design B are the same as given for Design A for frogs No. 16 to No. 20, inclusive, with the following modifications:

8. Heel

The heel end of manganese point is placed where the spread between gage lines is $4\frac{1}{4}$ in. instead of $4\frac{3}{4}$ in.

9. Heel Block Extension

To correspond with rules for Design A.

10. Heel Rails

To correspond with rules for Design A.

11. Wing Rail

To correspond with rules for Design A, from heel down to opposite theoretical point at 4 in. out from gage line. The wing rail is then bent back on a straight line to meet guard line at opposite the point where the toe spread between gage line is 1 in. (equals $2\frac{1}{2}$ in. wide throat). Angle of this line with guard line to be not smaller than 1 in 8 (1 in 7.1 for No. 16 frog). In No. 18 and No. 20 frogs run line on angle of 1 in 8 from guard line from opposite the 1 in. toe spread and extend line of wing from notch to 4 in. from gage line at theoretical point until the two lines meet. Toe end of manganese wing is placed at opposite the 1 in. toe spread. Wing rail then follows a straight line through throat to a $2\frac{1}{4}$ in. spread between gage line, where it is again bent to the line of the frog angle.

12. Manganese Steel Body and Wings

To correspond with rules for Design A, commencing at the $4\frac{1}{4}$ in. heel spread to toe end of manganese wing at throat. Manganese body is extended beyond end of manganese wing toward toe as a filler between wing rails a distance of 10 in. with continuous bearing on top of base and under head and against web of rail from toe end of casting to second bolt through manganese wing.

13. Flangeway Fillers and Toe Blocks

Fillers between heel rail and wing rail same as Design A. Toe blocks are placed 2 in. from end of manganese steel body—1 block 20 in. long for No. 16 frog—2 blocks 2 in. apart, outer one 16 in. long—inner one 6 in. long for No. 18 frog; and 2 blocks 2 in. apart—outer one $16\frac{1}{2}$ in. long—inner one $9\frac{1}{2}$ in. long for No. 20 frogs.

14. Bolt Spacing

Rules for bolt spacing at the heel and heel block extension are the same as for Design A.

At the toe end the position of the first four bolts through the manganese steel body is constant: 2 in.-5 in.-6 in.-7 in. from end of body extension between wing rails. Bolts through toe block are spaced as follows: From first toe bolt through manganese body towards toe end of frog—No. 16 frog, 8 in.-12 in.; No. 18 frog, 7 in.-7 in.-12 in.; No. 20 frog, $8\frac{3}{4}$ in.-9 in.-12 in.

Body bolts between fixed position of bolts at heel and toe ends are spaced in the least number of equal spaces not exceeding 12 in. from c. to c. same as Design A.

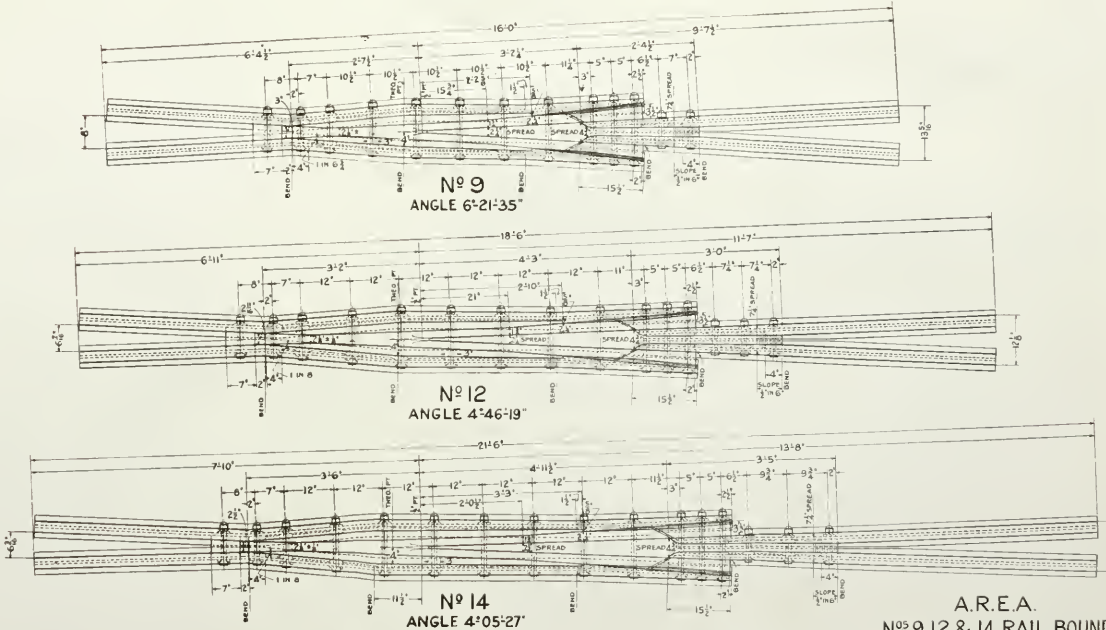
INDEX TO PLANS

Number of Frog	Plan No.
4	608
5	608
6	601
7	602
8	603
9	609
10	604
11	605
12	609
14	609
15	610
16	606
18	610
20	607
Preferred Names of Parts	690

A. R. E. A.
RULES FOR LAYING OUT
RAIL BOUND
MANGANESE STEEL FROGS
(COPIED FROM MANUAL

NOVEMBER, 1927

PLAN NO. 600

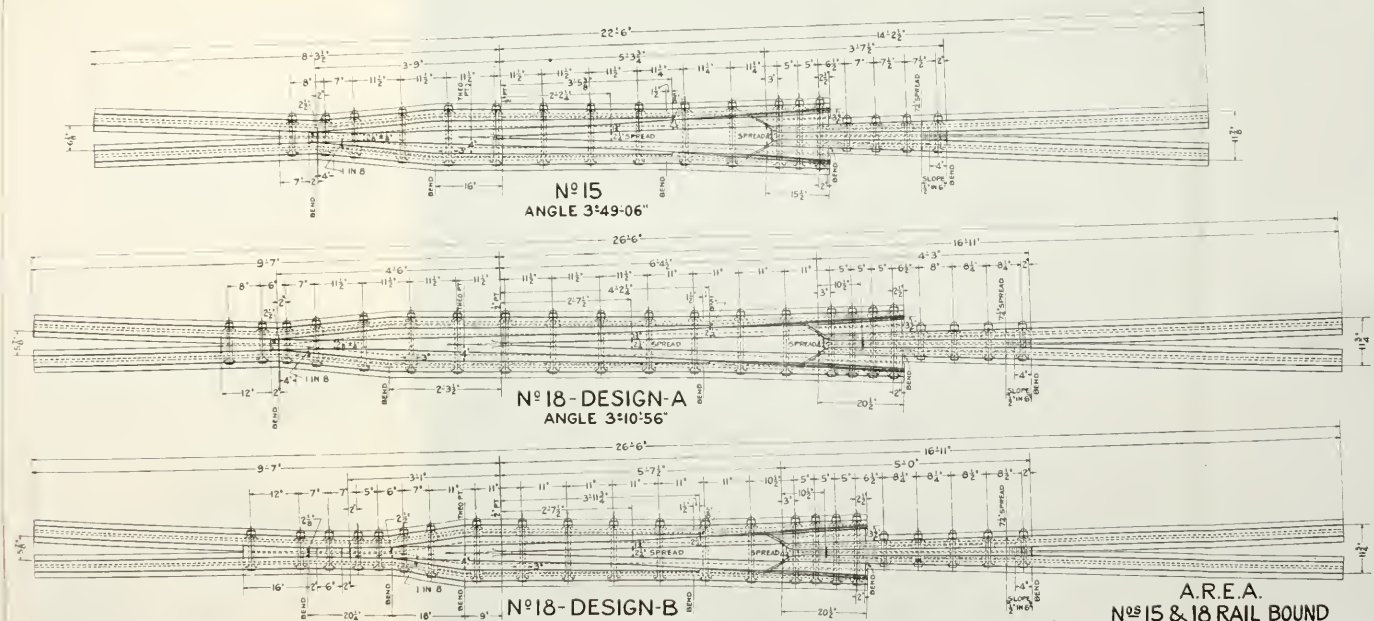


NOTE :- FOR SPECIFICATIONS, SECTIONS, AND OTHER DATA NOT SHOWN HEREON, SEE APPENDIX B AND PLANS 600, 603, 604 AND 605.

A.R.E.A. Nos 9, 12 & 14 RAIL BOUND MANGANESE STEEL FROGS

NOVEMBER 1927.

PLAN Nº 609.



NOTE :- FOR SPECIFICATIONS, SECTIONS, AND OTHER DATA NOT SHOWN HEREON, SEE APPENDIX B AND PLANS 600, 606 AND 607.

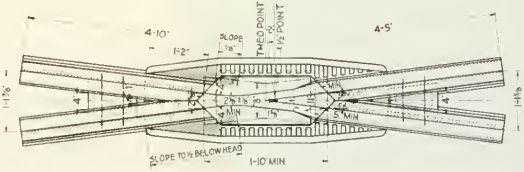
A.R.E.A.
Nos 15 & 18 RAIL BOUND MANGANESE STEEL FROGS.

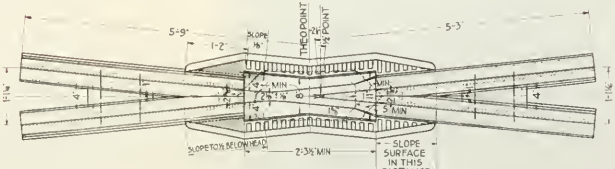
NOVEMBER 1927.

PLAN Nº 610.

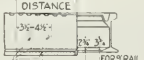
28

Nº 4 FROG





Nº5 FROG



DRILL 1⅛" DIAM HOLES IN BASE AND WEB OF RAILS TO PROVIDE FOR PROPER IRON BINDING

NOTE
METHOD OF FASTENING INSERT SUBJECT TO THE APPROVAL OF THE PURCHASER
FOR SECTIONS AND DETAIL OF POINT SEE PLAN 986
MANGANESE CENTERS MAY BE MADE EITHER AS SHOWN IN SOLID OR DOTTED LINES
THE IRON BINDING MAY BE PARALLEL WITH PLATE AS SHOWN ON ILLUSTRATION OF Nº5 FROG

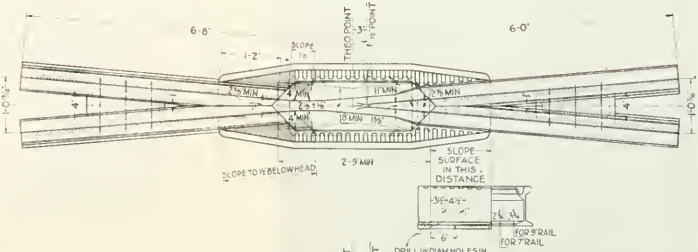
A. R. E. A.
Nºs 4 AND 5 FROGS
IRON BOUND MANGANESE STEEL CENTER
FOR 7" AND 9 GIRDER RAILS
Nº4 ANGLE 14°11'50"
Nº5 ANGLE 11°25'16"

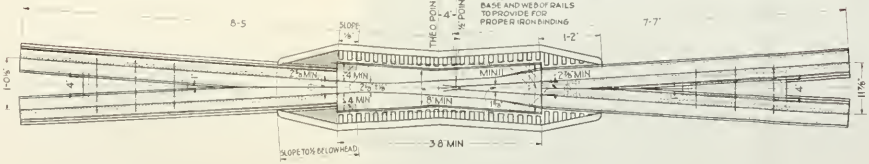
NOVEMBER, 1927

PLAN Nº 984

28

Nº6 FROG





Nº8 FROG

NOTE
METHOD OF FASTENING INSERT SUBJECT TO THE APPROVAL OF THE PURCHASER
FOR SECTIONS AND DETAIL OF POINT SEE PLAN 986
MANGANESE CENTERS MAY BE MADE EITHER AS SHOWN IN SOLID OR DOTTED LINES
THE IRON BINDING MAY BE PARALLEL WITH PLATE AS SHOWN ON ILLUSTRATION OF Nº8 FROG

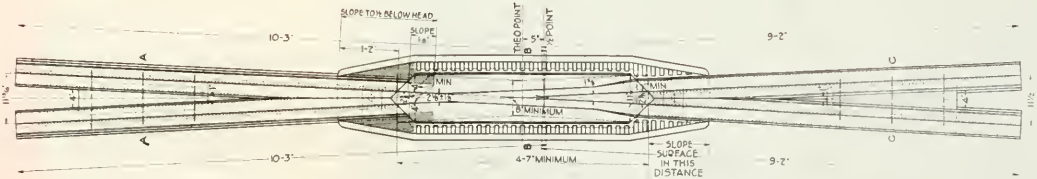
A. R. E. A.
Nº 6 AND 8 FROGS
IRON BOUND MANGANESE STEEL CENTER
FOR 7" AND 9" GIRDER RAILS
Nº6 ANGLE 9°31'38"
Nº8 ANGLE 7°09'10"

NOVEMBER, 1927

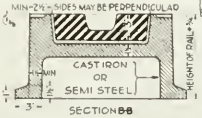
PLAN Nº 985

28

Nº10 FROG

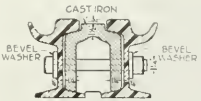


SECTION A-A



SECTION B-B

*DRILL 1⅝" DIAM HOLES IN BASE AND WEB OF RAILS TO PROVIDE FOR PROPER IRON BINDING



SECTION C-C

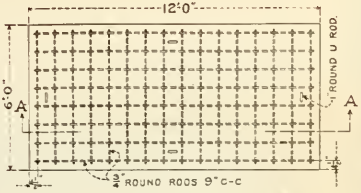
DETAIL OF POINT AND FLANGEWAY

NOTE
METHOD OF FASTENING INSERT SUBJECT TO THE APPROVAL OF THE PURCHASER
MANGANESE CENTERS MAY BE MADE EITHER AS SHOWN IN SOLID OR DOTTED LINES
THE IRON BINDING MAY BE PARALLEL WITH PLATE AS SHOWN ON ILLUSTRATIONS OF Nos 5 AND 8 FROGS

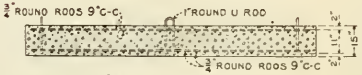
A. R. E. A.
Nº10 FROG
IRON BOUND MANGANESE STEEL CENTER
FOR 7" AND 9" GIRDER RAILS
Nº10 ANGLE 5°43'29"

NOVEMBER, 1927

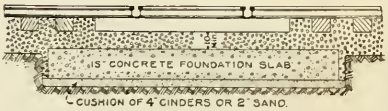
PLAN Nº 986



PLAN OF FOUNDATION SLAB.



SECTION A-A.



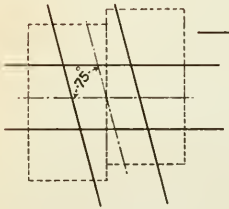
TYPICAL CROSS — SECTION THROUGH CROSSING.

REINFORCED CONCRETE FOUNDATION

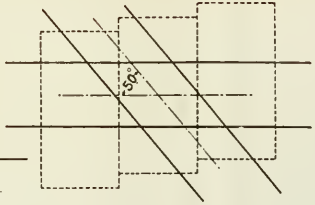
THIS TYPE OF REINFORCED CONCRETE FOUNDATION RECOMMENDED ONLY FOR CROSSINGS OF ANGLES 40 DEGREES AND OVER.

INSTEAD OF MAKING THE CONCRETE FOUNDATION OF STANDARD 6 FT. AND 12 FT. PRE-CAST SLABS, SPECIAL SLABS MAY BE USED THAT MORE NEARLY FIT THE ANGLE OF THE CROSSING

NOTE: PROVIDE SUITABLE DRAINAGE FOR CROSSING.



LAYOUT
FOR ALL CROSSING ANGLES FROM 80° TO 90° USE 2 SLABS



LAYOUT
FOR ALL CROSSING ANGLES FROM 40° TO 60° USE 3 SLABS

PILE FOUNDATIONS

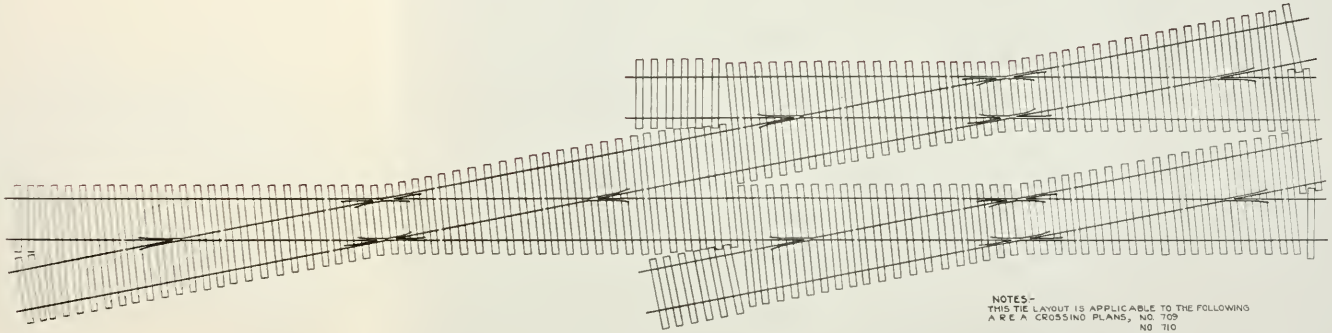
THERE ARE TWO TYPES OF PILE FOUNDATIONS. ONE IN WHICH A TIMBER FRAME WORK IS SUPPORTED ON PILES AND DIRECTLY ON TOP OF WHICH IS PLACED THE RAILROAD CROSSING, IN THE SECOND TYPE, PILES ARE DRIVEN AS CLOSELY TOGETHER AS PRACTICABLE, OVER WHICH IS PLACED 12 IN TO 15 IN OF BALLAST TO SUPPORT THE CROSSING TIES

PILE FOUNDATIONS ARE RECOMMENDED WHERE FILLED GROUND OR A MARSH IS ENCOUNTERED

A.R.E.A.
DESIGN OF
REINFORCED CONCRETE AND PILE
CROSSING FOUNDATIONS

NOVEMBER, 1926
REVISED NOVEMBER, 1927

PLAN No. 721



DRAWN AT 10'

NOTES:-
THIS TIE LAYOUT IS APPLICABLE TO THE FOLLOWING A.R.E.A. CROSSING PLANS, NO. 709
NO. 710
NO. 767
NO. 768
NO. 775

PLATES -SEE PARAGRAPHS 8-10-11 PLAN 700

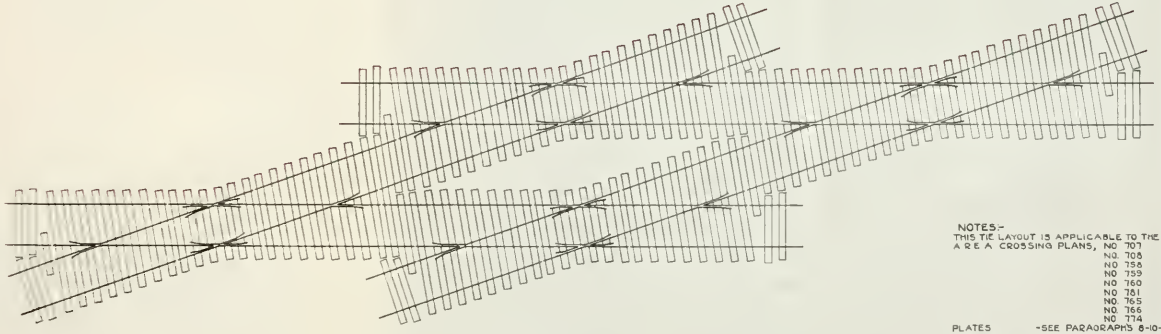
DRAINAGE -CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER ABOVE SUB-GRADE WILL BE TAKEN OFF.

BALLAST -A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.

CROSSING TIES -CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING.

A. R. E. A.
TIE LAYOUT FOR RAILROAD CROSSINGS
ANGLES 8°10' TO 14°15'

NOVEMBER 1927 PLAN 719-A



DRAWN AT 20°

NOTES:-

THIS TIE LAYOUT IS APPLICABLE TO THE FOLLOWING A.R.E.A. CROSSING PLANS, NO 707
NO 708
NO 758
NO 759
NO 760
NO 761
NO 765
NO 766
NO 774

PLATES -SEE PARAGRAPHS 8-10-11 PLAN 700.

DRAINAGE -CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER ABOVE SUB-GRADE WILL BE TAKEN OFF

BALLAST -A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.

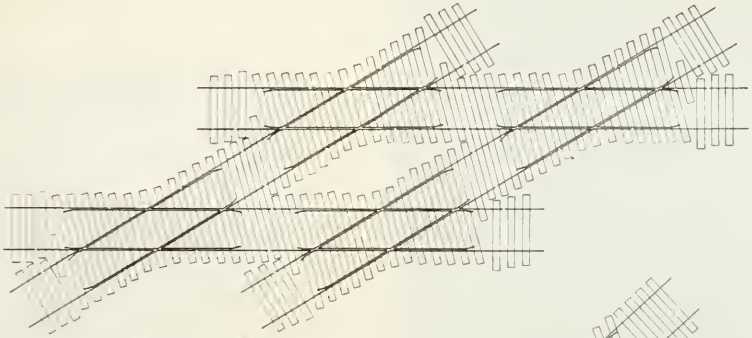
CROSSING TIES -CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING.

A. R. E. A.

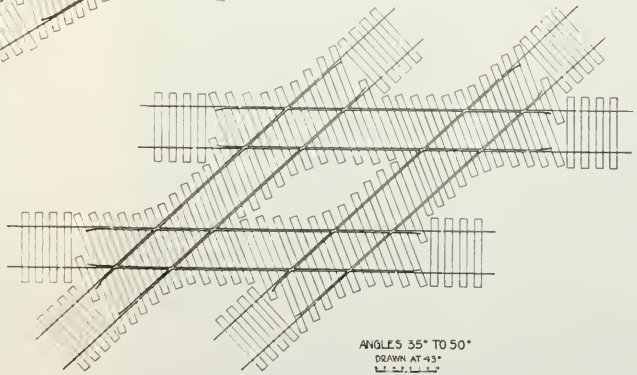
TIE LAYOUT FOR RAILROAD CROSSINGS

ANGLES 14°15' TO 25°

NOVEMBER 1927 PLAN 719-B



ANGLES 25° TO 35°
DRAWN AT 30°00'
Scale -



ANGLES 35° TO 50°
DRAWN AT 43°
Scale -

NOTES:-
THIS TIE LAYOUT IS APPLICABLE TO THE FOLLOWING A.R.E.A. CROSSING PLANS, ANGLES 25° TO 35°, ANGLES 35° TO 50°.

PLAN NO. 705	PLAN NO. 703
706	704
756	754
757	755
763	762
764	772
773	775

PLATES - SEE PARAGRAPHS 8-10-11 PLAN 700.

DRAINAGE - CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER ABOVE SUB-GRADE WILL BE TAKEN OFF.

BALLAST - A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.

CROSSING TIES - CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING.

CONCRETE CROSSING FOUNDATION - SEE PLAN NO. 721

A. R. E. A.
TIE LAYOUT FOR RAILROAD CROSSINGS
ANGLES 25° TO 50°

NOVEMBER 1927 PLAN 719-C

Appendix E

(5) DESIGN AND SPECIFICATIONS FOR FOUNDATIONS UNDER RAILWAY CROSSINGS; ALSO PROPER METHODS FOR TIE SPACING AND TIMBERING UNDER RAILWAY CROSSINGS

O. F. Harting, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, C. W. Breed, H. W. Brown, J. E. Deckert, F. S. Hales, W. J. Harris, H. D. Knecht, E. R. Lewis, F. H. Masters, J. B. Myers, A. J. Neafie, W. H. Petersen, I. H. Schram, G. J. Slibeck, E. D. Swift.

The plans presented in this Appendix have been prepared in conference with the Standardization Committee of the Manganese Track Society.

Plan No. 721, dated November, 1926, design of reinforced concrete crossing foundations, was presented last year as information to invite criticism.

This plan, dated revised November, 1927, entitled A.R.E.A. design of reinforced concrete and pile crossing foundations, is now offered for adoption as recommended practice, revised to include additional notes as to details and as to pile foundations.

The following series of plans showing tie layouts for crossings are presented as information to invite criticism:

Plan No. 719-A, dated November, 1927, A.R.E.A. tie layout for railroad crossings, angles 8 deg. 10 min. to 14 deg. 15 min.

Plan No. 719-B, dated November, 1927, A.R.E.A. tie layout for railroad crossings, angles 14 deg. 15 min. to 25 deg.

Plan No. 719-C, dated November, 1927, A.R.E.A. tie layout for railroad crossings, angles 25 deg. to 50 deg.

The Committee has under consideration plans of tie layouts for crossings of angles 50 to 90 deg. for presentation in a report at a later date.

Conclusions

The Committee recommends that the following plan submitted herewith be adopted as recommended practice and printed in the Manual:

Plan No. 721, dated November, 1927, reinforced concrete and pile crossing foundations.

The Committee also recommends that the following plans submitted herewith be received as information:

Plan No. 719-A, dated November, 1927, tie layout for railroad crossings, angle 8 deg. 10 min. to 14 deg. 15 min.

Plan No. 719-B, dated November, 1927, tie layout for railroad crossings, angle 14 deg. 15 min. to 25 deg.

Plan No. 719-C, dated November, 1927, tie layout for railroad crossings, angles 25 to 50 deg.

Appendix F

(6) STUDY AND REPORT ON METHODS OF REDUCING RAIL WEAR ON CURVES WITH PARTICULAR REFERENCE TO OILING THE RAIL OR WHEEL FLANGES, COLLABORATING WITH COMMITTEE IV—RAIL

C. M. McVay, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, W. H. Bevan, W. G. Brown, H. G. Clark, L. W. Deslauriers, J. M. Fair, C. J. Geyer, E. T. Howson, H. D. Knecht, F. H. Masters, G. M. Strachan, E. D. Swift, J. R. Watt.

Quite a number of railroads are oiling rail and flanges both by hand and with devices made for this purpose. There seems to be no question but that desirable economies can be effected by rail and flange oiling and roads which have taken up this practice claim considerable saving through it. Wear on the high rail of the curve is greatly reduced, life of ties is lengthened due to less re-gaging, less tread wear occurs on the low rail, curve resistance is lessened and there is reduced wear on flanges.

To secure proper results from oiling, it is essential that the proper oil be used. The viscosity of the oil is important, as the oil must be sticky enough to adhere to the flanges for application to the rail ahead and must function through a considerable temperature range. It is also essential that the oil be continuously applied, either to the wheels of every train using the track or to the rail ahead of every train, as less frequent applications of oil are not satisfactory.

Your Committee feels that this subject should be investigated further as more roads are now engaging in the practice of oiling and in the next year or two considerable additional information should be available on this subject.

The Committee also proposes to consider other than oiling devices which are claimed to reduce rail and flange wear.

Conclusions

The Committee recommends that this report be received as information only and that the subject be continued, collaborating with Committee IV—Rail.

Appendix G

(7) MAKE CRITICAL REVIEW OF MATERIAL IN FORMER PROCEEDINGS WITH RESPECT TO THE CAUSE AND EFFECT OF BRINE DRIPPINGS, COLLABORATING WITH COMMITTEE IV—RAIL, AND COMMITTEE XV—IRON AND STEEL STRUCTURES

W. G. Arn, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, W. H. Bevan, W. G. Brown, J. M. Fair, E. T. Howson, T. T. Irving, J. C. Mock, E. D. Swift.

A review of the material in former Proceedings yielded only the following of interest:

In 1911 the Sub-Committee on Brine Drippings recommended as follows:

"1. All salt-water drippings should be retained in the ice tanks and drained off only at icing stations.

"2. The total capacity of drain openings should not exceed the capacity of traps, and the capacity of drains and traps should be sufficient to release all drippings within the time limit of icing the train.

"3. The mechanism adopted for handling drain valves should be simple and positive, and so designed as to insure closing the valves before hatch plugs can be returned to their places.

"4. Salt drippings should be conducted from ice tanks through the drain valves above described and thence to the outside of the car through the regular traps and drain pipes.

"The packing companies have co-operated with your Committee in their investigation, and have expressed their willingness to put into effect the practice recommended by your Committee, if these recommendations meet with the approval of the Master Car Builders Association.

"Arrangements were subsequently made for taking care of brine drippings in accordance with the above recommendations and the American Railway Association Code of Rules (M.C.B.) governing the condition of, and repairs to, freight and passenger cars for the interchange of traffic, as effective January 1, 1927, as follows:

> 'Rule 3—Cars not conforming to the following requirements will not be accepted in interchange, or from car owners, as specified.
>
> '(2)—Refrigerator cars equipped with brine tanks. Suitable device for retaining the brine between icing stations. From owners.'

"The Proceedings of 1926 (Volume 27, page 467) give an interesting report of the effect of brine drippings on track appliances, but the data are not conclusive."

Information recently obtained shows the following:

Most of the roads enforce interchange requirements in Rule 3 quoted above as to meat refrigerator cars, this rule having been put into effect January 1, 1923. For the United States as a whole, the rule is enforced

about 95 per cent. This rule applies only to refrigerator cars constructed for meat shipments and equipped with brine tanks, and does not apply to the type of refrigerator cars in which fruits and vegetables are shipped.

Beginning in 1923, salt is used to a limited extent in refrigerator cars other than meat cars.

The practice of using salt in refrigerator cars other than meat cars is increasing, it being used in the shipment of certain berries, other fruits, melons, vegetables, fish, poultry and dairy products.

It is anticipated that the use of salt in cars other than meat cars will continue to increase, and as a consequence brine drippings will continue to damage rail, track fastenings, bridges and interfere with signals unless protection is provided.

Information obtained from various railroads indicates that no one protective coating, which is entirely satisfactory, has been found. Among the coatings which have been used more or less successfully are the following:

Crude oil
Asphalt and Asphalt Compounds
Tar and Tar Compounds
Mastic Paint.

A possible solution of this problem is the use of some refrigerant other than ice, preferably one which has no deleterious effect on refrigerator cars, track structure and the products which are being shipped. One such possible refrigerant is solid carbon dioxide (so-called "Dry Ice"). The cost of this material is as yet so high that its use as a substitute for ice and salt or ice alone may not be justified, but the satisfactory results obtained from its use and the increasing extent of its use promise increased manufacturing facilities with a possible decrease in cost, which makes it a promising possibility for refrigerator car shipments.

Conclusions

The Committee recommends that this report be received as information only and the subject be continued with the scope broadened to include investigation of promising substitute refrigerants.

REPORT OF COMMITTEE VIII—MASONRY

C. P. Richardson, *Chairman;*
J. T. Andrews,
W. M. Beach,
J. A. Bohland,
G. E. Boyd,
T. L. Condron,
W. T. Davis,
T. L. D. Hadwen,
M. Hirschthal,
A. C. Irwin,
G. M. Johnson,
A. R. Ketterson,
J. A. Lahmer,
Job Tuthill, *Vice-Chairman;*
A. N. Laird,
J. F. Leonard,
Blair Ripley,
F. E. Schall,
L. W. Skov,
A. W. Smith,
T. M. von Sprecken,
G. E. Tebbetts,
R. A. Van Ness,
C. C. Westfall,
P. H. Winchester,
J. J. Yates,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report on:

(2) Principles of design of concrete, plain and reinforced, for use in railroad structures.

(3) Report on progress being made in methods of concrete manufacture.

(5) Specifications for foundation work, including excavation, cofferdams, piling, etc.

(6) Outline of work for the ensuing year.

Action Recommended

(2) Principles of design of concrete, plain and reinforced, for use in railroad structures:

(a) That section on "Flexure of Reinforced Concrete T-Beams," paragraphs 137 to 143, inclusive (Appendix A), be adopted for incorporation in the Manual as recommended practice.

(b) That the data on concrete encasement of steel members, concrete piles, reinforced concrete columns and arches (Appendix A), and monograph on flat slabs (Appendix B), be received as information.

(c) That the Board of Direction take under advisement the formation of a Joint Committee of Affiliated Engineering Societies to make a study and report on "The Concrete Encasement of Steel Members."

(3) Report on progress being made in methods of concrete manufacture.

That the report upon progress being made in methods of Concrete Manufacture (Appendix C) be received as information.

(5) That the typical specifications for foundations (Appendix D) be received as information.

(6) That the progress report on Waterproofing of Railway Bridges (Appendix E), be received as information.

Recommendations for Future Work

1. Revision of Manual.

2. Principles of design of plain and reinforced concrete for use in railway buildings, bridges and culverts, collaborating with Committee VI—Buildings and Committee XV—Iron and Steel Structures.

3. Report upon progress being made in methods of concrete manufacture.

4. Maintain contact with Joint Committee on Standard Specifications for Concrete and Reinforced Concrete and report to the Association.

5. Prepare specifications for foundations, including excavation, cofferdams, piling, etc.

6. Study and report upon general practices for waterproofing railway structures, collaborating with Committee VI—Buildings, and Committee XV—Iron and Steel Structures.

7. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Masonry,

C. P. Richardson, *Chairman.*

Appendix A

Your Committee has continued the study of the specifications for Reinforced Concrete "T" Beams, Columns and Flat Slabs, as presented in the Joint Committee Report, and presents a new specification for "Flexure of Reinforced Concrete 'T' Beams" (paragraphs 137-143, inclusive) for incorporation in the Manual, as recommended practice.

In view of the marked difference of opinion as to the column formulas presented in the Joint Committee Specifications, your Committee presents a progress report on this subject (Section IV) and requests written discussion of this report from the membership of the Association as an aid to the Committee in the formulation of a recommended practice for the design of reinforced concrete columns.

Appendix B

Your Committee has reviewed the Specifications for Flat Slabs, as presented in the Joint Committee Report and reports progress. It is felt that the Joint Committee Report should be enlarged to include provisions for the design of structures subject to heavy locomotive concentrations, but, as your Committee desires further time for study and report on this subject, it presents herewith a monograph by one of the members, entitled "Regulations for Flat Slabs" (Four-Way System), and requests written discussion of this subject during the coming year.

Appendix A

(2) PRINCIPLES OF DESIGN OF CONCRETE, ETC.

M. Hirschthal, Chairman, Sub-Committee; Job Tuthill, T. L. Condron, A. C. Irwin, A. R. Ketterson, A. N. Laird, J. F. Leonard, A. W. Smith, T. M. von Sprecken, G. E. Tebbetts, C. C. Westfall.

I—FLEXURE OF REINFORCED CONCRETE T-BEAMS

Flexure Formulas

137. Computations of flexure in reinforced concrete T-beams shall be based on the following formulas:

(a) Neutral Axis in the Flange.

Use formulas for rectangular beams and slabs in Section 85.

(b) Neutral Axis below the Flange.

Position of neutral axis,

$$kd = \frac{2nd\,A_s + bt^2}{2nA_s + 2bt}$$

Position of resultant of compressive stresses,

$$z = \left(\frac{3kd - 2t}{2kd - t}\right)\frac{t}{3}$$

Arm of resisting couple,

$$jd = d - z$$

Compressive unit stress in extreme fiber of concrete,

$$f_c = \frac{Mkd}{bt\,(kd - \tfrac{1}{2}t)\,jd} = \frac{f_s}{n}\left(\frac{k}{l - k}\right)$$

Tensile unit stress in longitudinal reinforcement,

$$f_s = \frac{M}{A_s jd}$$

The above formulas neglect compression in the web below the bottom of flange. See footnote for exact formulas where thickness of the flange is small as compared with the depth of the web.*

$$kd = \sqrt{\frac{2ndA_s + (b - b')\,t^2}{b'} + \left(\frac{nA_s + (b - b')\,t}{b'}\right)^2} - \left(\frac{nA_s + (b - b')\,t}{b'}\right.$$

Position of resultant of compressive stresses,

$$z = \frac{(kd^2 - \tfrac{2}{3}t^2)\,b + [((kd - t)^2\,(t + \tfrac{1}{3}\,(kd - t))]b'}{t\,(2kd - t)\,b + (kd - t)^2 b'}$$

*Position of neutral axis.

Arm of resisting couple,

$$jd = d - z$$

Compressive unit stress in extreme fiber of concrete,

$$f_c = \frac{2\,Mkd}{((2kd - t)\,bt + (kd - t)^2 b')\,jd}$$

Tensile unit stress in longitudinal reinforcement,

$$f_s = \frac{M}{A_s jd}$$

Notation

138. The symbols used in T-Beam formulas are as defined in Section 86 together with the following:

b' = width of web of T-Beam.
t = thickness of flange of T-Beam.
L = distance between lateral supports.

General

139. The slab forming the flange of the T-Beam shall be designed and constructed as an integral part of the beam. Effective and adequate bond and shear resistance shall be provided in beam and slab construction at the junction of the web of the T-Beam and the slab.

Flange Width and Thickness

140. (a) For symmetrical T-Beams in slab and beam construction the effective flange width to be used in the design shall not exceed one-fourth the span length of the beam, nor shall the overhanging flange width on either side of the web exceed six times the flange thickness or one-half the clear distance between faces of the adjacent T-Beam webs.

(b) For T-Beams having a flange on one side only, the effective flange width to be used in the design shall not exceed one-tenth of the span length of the beam, nor shall the overhanging flange width beyond the face of the web exceed four times the flange thickness or one-half the distance from the face of its web to that of the adjacent T-Beam.

(c) Isolated beams, in which the tee form is used only for the purpose of providing additional compression area, shall have a flange thickness not less than one-half the web width and a total flange width not more than three times the web width. The distance between lateral supports shall not exceed sixteen times the least width of the compression flange. The allowable compressive stress in the flange shall not exceed $f_c\left(1.2 - \frac{L}{30b}\right)$ but in no case shall it exceed f_c.

Transverse Reinforcement

141. The area of steel near the upper face of the flange of T-Beam effective as transverse reinforcement shall be not less than 0.3 of one per cent of section of the slab and shall extend, not less than one-quarter of the span

into the slab, each side of the axis of the T-Beam. The spacing of bars shall not be greater than three times the effective depth of slab nor more than 18 in.

Compressive Stress at Supports of Continuous T-Beams

142. Provision shall be made for the compressive stress at the support in continuous T-Beam construction, considering the web section as a rectangular beam with both tensile and compressive reinforcement.

Shear

143. The flange overhang of T-Beams shall not be considered as effective in computing the resistance of the beam to horizontal and vertical shears or the diagonal tension resistance of the beam.

II—CONCRETE ENCASEMENT OF STEEL MEMBERS

Concrete encasement of steel members has been common practice for many years, but never in design has it been permitted to consider the concrete as aiding the steel except for columns with a concrete core where it is sometimes taken into consideration. In fact, it is considered necessary to increase the amount of steel required in order to carry the weight of the concrete encasement. Existing building codes require that this be done.

A considerable number of tests have been made during the last five year to determine the relative strength value of the concrete, and while it is felt that these tests are neither sufficient in number nor sufficiently varied in character to justify definite recommendations, they indicate the following:

(1) That steel and concrete act together to form a composite member.
(2) That concrete encasement can be applied to a steel member so as to give a greater strength than that of the unencased steel.

Your Committee has reviewed these tests with great interest and presents a bibliography as information.

The importance of the subject, in view of the data developed by these tests, would appear to your Committee sufficient to warrant a comprehensive study, requiring additional tests, and it would further appear that such a study, to be of value, should best be made through the joint activities of all engineering societies and by a committee similar in organization to the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.

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"Calculation of Steel Structures"—W. Cyril Cocking.

Vol. XVI. "Reinforced Concrete in Practice," by Alban H. Scott, M.S.A.; MCl.

1922-1923—Tests at National Physical Laboratory, Teddington, England. Tests at plant of Dominion Bridge Company, by Professors H. M. McKay of McGill University, Peter Gillespie of the University of Toronto, and C. Leluan of University of Montreal, reported in Engineering Journal, August, 1923.

1925 —"Haunching as Reinforcement for Steel Beams," paper by Prof. C. R. Young of the University of Toronto, published in The Canadian Engineer, December 22, 1925.

"Steel I-Beams Haunched in Concrete," by Prof. Peter Gillespie and R. C. Leslie, Bulletin No. 5, 1925, University of Toronto.

1926 —"Steel I-Beams Haunched in Concrete," by Prof. H. M. McKay, Dean, Faculty of Applied Science, McGill University. Paper presented before American Institute of Steel Construction, and published in The Canadian Engineer, November 30, 1926.

1927 —"Tests of Corroded Steel Beams Restored with Concrete," by Prof. J. R. Shank, Associate Professor of Structural Engineering, Ohio State University. Published in Engineering News-Record, April 7, 1927.

"Concrete Encased Structural Steel," by Prof. Clyde T. Morris, Ohio State University.

III—PRE-MOLDED CONCRETE PILES

Pre-molded concrete piles may be classified in two divisions:

(a) Piles for foundations.
(b) Piles for trestle work or for uses where piles are only partially imbedded in the ground.

(a) For foundation purposes, either pre-molded piles or piles molded in place may be used. The pre-molded pile must be designed to carry the required load and to withstand the stresses due to handling and driving.

On account of the varied requirements for each type of foundation, a standard design does not appear feasible.

(b) The pre-molded concrete pile for trestle or similar uses, in addition to being designed for the requisite strength for use in foundations, must be designed for bending without lateral support, or for action as a reinforced concrete column throughout the portion not imbedded in the ground or concrete cap.

Your Committee, at this time, is not prepared to recommend a design for a pre-molded concrete pile for trestle purposes, but submits a typical design of a pile (Fig. 1) which is designed and constructed as standard practice by a Class "A" railroad, in accordance with the following specifications:

Concrete shall be of such a mixture as to give a strength of 3000 lb. per sq. in. at 28 days.

The design shown is a straight pile of octagonal section, and is based on an assumed penetration of 20 ft. Soft soil or mud shall not be considered as part of the pile penetration. For the shorter piles, a maximum unsupported length of 20 ft. is assumed to act as a column; for length of 40 ft., a maximum unsupported length of 25 ft. is assumed to act as a column.

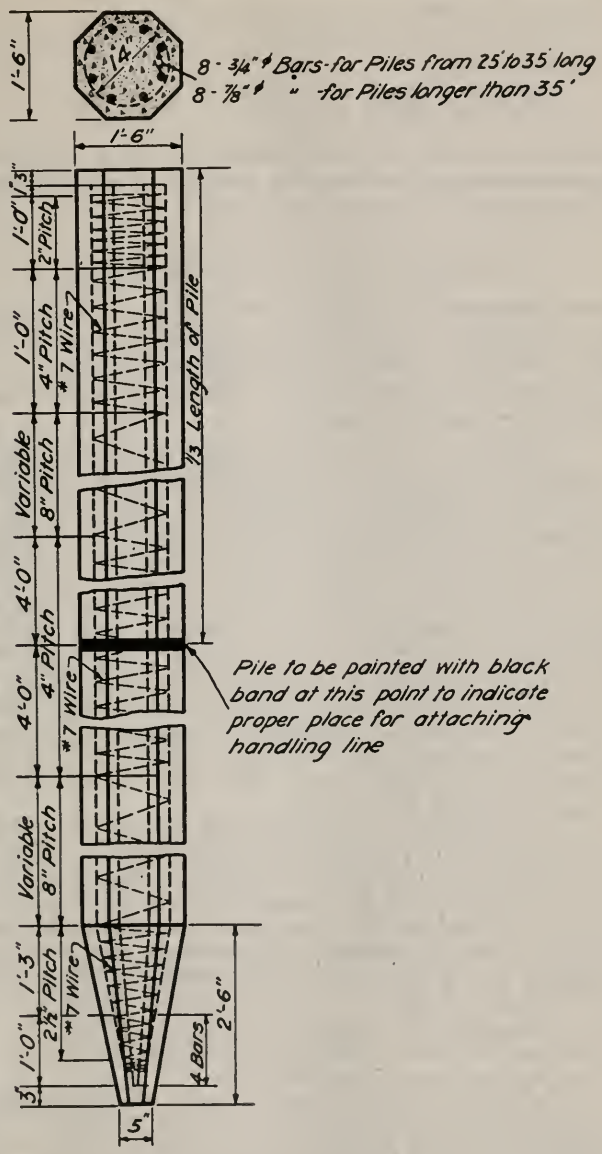

Fig. 1—Detail of Reinforced Concrete Pile 25 Ft. to 40 Ft. Lengths

The pile is designed for column action as follows:

35 ft. pile—20 ft. unsupported.....79½ tons
40 ft. pile—25 ft. unsupported.....84 tons

Handling stresses:

40 ft. pile f_c 400-lb. per sq. in.
f_s 8800-lb. per sq. in.

Investigations, thus far made, indicate that the 18-inch section and a spiral reinforcement are preferable for protection of reinforcement, bearing power and resistance to handling and driving.

IV—REINFORCED CONCRETE COLUMNS

Your Committee, in considering the subject of reinforced concrete columns, studied the results of column tests made by Prof. M. O. Withey, reported in Bulletin No. 466 of the University of Wisconsin.

The following are some of the conclusions stated by Prof. Withey which should be especially considered:

"Although the yield point of a reinforced concrete column is practically independent of the percentage of spiral reinforcement, the ultimate strength and the toughness are directly affected by it. On account of the excessive deformations accompanying loads beyond the yield point, on account of the probability that both yield point and ultimate strength are less in repeated or long time load tests than in the progressive load tests ordinarily made in the testing machine, and on account of the uncertainties which always surround the hypothesis adopted in designing, *good practice demands that only a portion of the stress producing disintegration of the outside shell be used as a working stress.** Consequently, only enough lateral reinforcement is needed to prevent the longitudinal rods from bulging outward, and to provide an additional factor of safety against an overload by increasing the toughness and raising the ultimate strength somewhat above the yield point. From these tests one per cent of a closely spaced spiral of high carbon steel seems to be sufficient for this purpose.

"By the addition of longitudinal steel the yield point, ultimate strength, and stiffness of a spirally reinforced column can be considerably increased. If maximum economy in floor space is desired, if a column is so long or is so eccentrically loaded that tension exists on a portion of the cross-section, or if a large dead load must be sustained by the column while the concrete is green, a high percentage of longitudinal reinforcement may often be advantageously employed. Such reinforcement is also a valuable safeguard against failure due to flaws in the concrete. In general, however, cement is a more economical reinforcement than steel. Therefore, for ordinary constructions, it does not seem advantageous to use in combination with a rich concrete more than two or three per cent of longitudinal steel.

"The amount of data presented on tests of columns subjected to repeated or time loadings is far too small to warrant drawing definite conclusions as to limiting stress for repeated loadings which will hold true for all kinds of columns and for an infinite number of repetitions, or for a prolonged loading. However, it does appear

*Italics by Committee.

from the results presented that there is practically no increase in set or deformation after a few repetitions of loads equal to 40 to 50 per cent of the yield points of the columns tested. The results of the repeated load tests also plainly indicate that there is considerable additional strength and toughness afforded by the spiral after the yield point of the longitudinal steel has been passed.

"Briefly summarizing the foregoing, it seems economical to use for reinforced concrete columns a very rich mixture, and advantageous to employ about one per cent of closely spaced high carbon steel lateral reinforcement combined with two or three per cent of longitudinal reinforcement. From the test data presented, it seems apparent that such columns, centrally loaded, may be subjected to a static working stress equal to one-third of the stress at yield point.

"Closely spaced spiral reinforcement will greatly increase the toughness and will considerably increase the ultimate strength of a concrete column, *but will not materially affect the yield point.** The ultimate strength under dead load will doubtless be somewhat less than the value obtained from a testing machine. Since spiral reinforcement should be employed principally as a factor of safety against sudden collapse, more than one per cent does appear to be necessary. On account of lack of stiffness in columns made from this grade of concrete and reinforced with spirals only, it seems necessary to use some longitudinal steel.

"Longitudinal steel in combination with such spiral reinforcement raises the yield point and ultimate strength of a column and increases its stiffness. As was shown in Bulletin No. 300, columns reinforced with longitudinal steel only are brittle and fail suddenly when the yield point of the steel is reached; but they are considerably stronger than plain concrete columns made from the same grade of concrete.

"From behavior under test of the columns reinforced with spirals and vertical steel and the results computed, it would seem that a static load equal to 30 to 40 per cent of the yield point would be a safe working load."

A comparison of the allowable stresses for spirally hooped reinforced concrete columns recommended by the "Joint Committee" with the results of Professor Withey's tests shows that these recommended unit stresses apparently correspond with the conclusions of Professor Withey, that a safe working load would seem to be a static load equal to 30 to 40 per cent of the yield point. Your Sub-Committee therefore presents as tentative, formulas Nos. 42 and 43 for determining the allowable stress in spirally reinforced concrete columns as recommended by the Joint Committee and given in Bulletin No. 269 of the A.R.E.A.

Your Sub-Committee also presents the following text as tentative:

REINFORCED CONCRETE COLUMNS

Limiting Dimensions

1. The following sections on reinforced concrete columns are based on the assumption of a short column. Where the unsupported length is greater than 40 times the least radius of gyration (40 R), the column shall be designed as a long column with suitable reduction in the allowable load.

*Italics by Committee.

Principal columns in buildings shall have a minimum diameter or thickness of 12 in. Posts that are not continuous from story to story shall have a minimum diameter or thickness of 6 in.

Unsupported Length

2. The unsupported length of reinforced concrete columns shall be taken as:

(a) In flat slab construction the clear distance between the floor and under side of the capital;

(b) In beam and slab construction the clear distance between the floor and the underside of the shallowest beam framing into the column at the next higher floor level;

(c) In floor construction with beams in one direction only, the clear distance between floor slabs;

(d) In columns supported laterally by struts or beams only, the clear distance between consecutive pairs (or groups) of struts or beams, provided that to be considered an adequate support, at least two such struts or beams shall meet the column at approximately the same level and the angle between the two planes formed by the axis of the column and the axis of each strut respectively is not less than 75 deg. nor more than 105 deg., and so connected to the columns that they will act as ties as well as struts.

(e) When haunches are used at the junction of beams or struts with columns, the clear distance between supports may be considered as reduced by two-thirds of the depth of the haunch.

Safe Load on Spiral Columns

3. The safe axial load on columns reinforced with longitudinal bars and closely spaced spirals enclosing a circular core shall be not greater than that determined by the formula:

where $P = A_c f_c + nf_c pA$

P = total safe axial load on column whose h/R is less than 40;

A = area of the concrete core enclosed within the spiral; the diameter of the core (or of the spiral) shall be taken as the distance center to center of the spiral wire;

p = ratio of effective area of longitudinal reinforcement to area of the concrete core;

$A_c = A\ (l - p)$ = net area of concrete core; and

f_c = permissible compressive stress in concrete =

$$300 + (0.10 + 4p)\ f'_c$$

The longitudinal reinforcement shall consist of at least six bars of minimum diameter of ½ in., and its effective cross-sectional area shall not be less than one per cent, nor more than six per cent, of that of the core.

Spiral Reinforcement

4. The spiral reinforcement shall be not less than one-fourth the volume of the longitudinal reinforcement nor less than one-half of one per cent of the core area. It shall consist of evenly spaced continuous spirals held firmly in place and true to line by at least vertical spacer bars. The spacing of the spirals shall be not greater than one-sixth of the diameter of the core and in no case more than 3 inches. The spiral reinforcement shall

meet the requirements of the Tentative Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement.

Protection of Reinforced Column

5. Reinforcement shall be protected everywhere by a covering of concrete cast monolithic with the core, which shall have a minimum thickness of 1½ in. in square columns and 2 in. in round or octagonal columns.

Safe Load on Columns with Lateral Ties

6. The safe axial load on columns reinforced with longitudinal bars and separate lateral ties shall be not greater than that determined by formula (Joint Committee formula 44)

$$P = (A'_c + A_s n) f_c$$

where A'_c = net area of concrete in the column (total column area minus area of reinforcement);
A_s = effective cross-sectional area of longitudinal reinforcement; and
f_c = permissible compressive stress in concrete and shall not exceed $0.15 f'_c$.

The amount of longitudinal reinforcement considered in the calculations shall be not more than 2 per cent nor less than 0.5 per cent of the total area of the column. The longitudinal reinforcement shall consist of not less than four bars of minimum diameter of ½ in., placed with clear distance from the face of the column not less than 1½ in.

Lateral Ties

6. Lateral ties shall be not less than ¼ in. in diameter, spaced not more than 8 in. apart.

Bending in Columns

7. Reinforced concrete columns subject to bending stresses shall be treated as follows:

(a) With Spiral Reinforcement.—The compressive unit stress on the concrete within the core area under combined axial load and bending shall not exceed by more than 20 per cent the value given for axial load by formula $f_c = 300 + (0.10 + 4p) f'_c$ (Joint Committee formula 43).

(b) With Lateral Ties.—Additional longitudinal reinforcement may be used if required and the compressive unit stress on the concrete under combined axial load and bending may be increased to $0.30 f'_c$. The total amount of reinforcement considered in the computations shall be not more than 4 per cent of the total area of the column.

Tension in the longitudinal reinforcement due to bending of the column shall not exceed 16,000 lb. per sq. in.

The accompanying diagram (Fig. 2) shows the values of f_c (the allowable stresses on the concrete in spirally reinforced columns) according to the formulas in the Joint Committee specifications and the values of the average stresses on the core areas.

Diagram (Fig. 3) shows the comparative column capacities for rodded and for spirally reinforced columns for one per cent and two per cent vertical reinforcement on columns ranging from 12 in. square, with 9-in. diameter core, to columns 36 in. square with 33-inch diameter core, all of 2000 lb. per sq. in. concrete, according to Joint Committee specifications. On this diagram are also plotted curves showing the capacities of rodded columns using $f_c = .15 f'_c$, as recommended by this Sub-Committee instead of $f_c = .20 f'_c$ given in the Joint Committee specifications. The recommendations of the Sub-Committee avoid the error of permitting greater loads on rodded columns than on spirally reinforced columns.

V—ARCHES

Concrete arches, whether plain or reinforced, shall be designed on the basis of the elastic theory applied to arches of variable moment of inertia.

This assumes fixedness with unyielding supports resulting in:

(1) Span remaining constant (horizontally).
(2) Springing lines remaining at constant elevation (vertically).
(3) Tangent to neutral axis at supports being at constant inclination.

Stresses shall be figured for dead load, live load, temperature changes, and rib shortening. Maximum stresses shall be the algebraic sum of all of them.

Maximum allowable compressive stress in the concrete shall not exceed ⅜ ultimate f_c. Reinforcing steel in tension shall not be stressed higher than 20,000 lb. per sq. in.

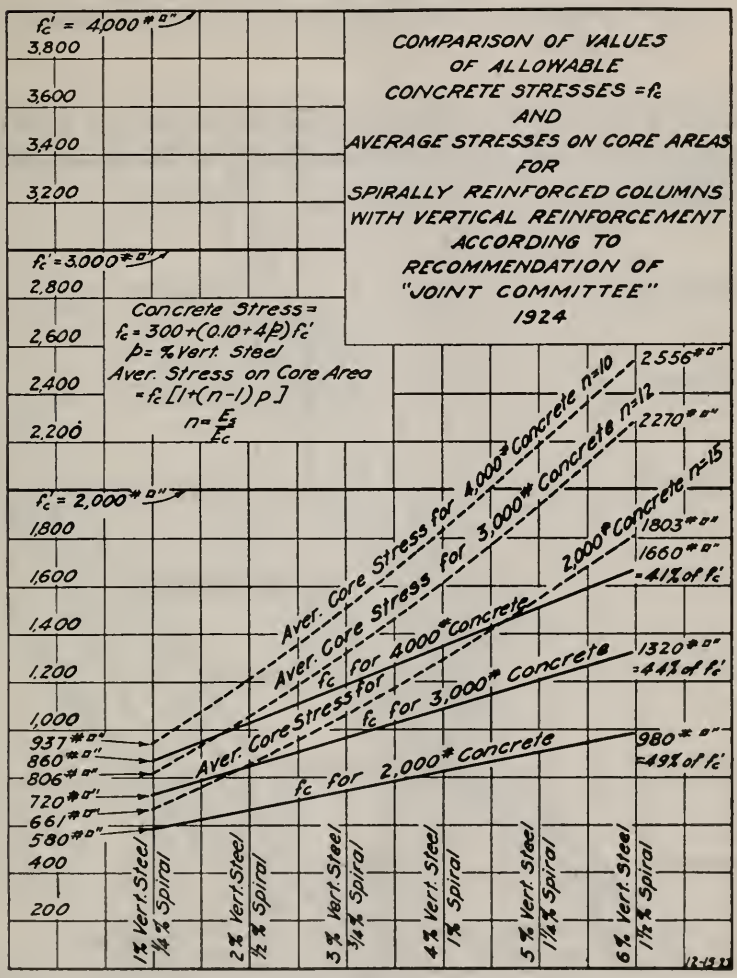
COMPARISON OF VALUES
OF ALLOWABLE
CONCRETE STRESSES = fc
AND
AVERAGE STRESSES ON CORE AREAS
FOR
SPIRALLY REINFORCED COLUMNS
WITH VERTICAL REINFORCEMENT
ACCORDING TO
RECOMMENDATION OF
"JOINT COMMITTEE"
1924
f'c = 4,000#□"
f'c = 3,000#□"
f'c = 2,000#□"
3,800
3,600
3,400
3,200
2,800
2,600
2,400
2,200
1,800
1,600
1,400
1,200
1,000
400
200
Concrete Stress =
fc = 300+(0.10+4p) f'c
p = % Vert. Steel
Aver. Stress on Core Area
= fc [1+(n-1) p]
n = Es/Ec
Aver. Core Stress for 4,000# Concrete n=10
Aver. Core Stress for 3,000# Concrete n=12
2,000# Concrete n=15
fc for 4000# Concrete
fc for 3,000# Concrete
fc for 2,000# Concrete
Aver. Core Stress for
2,556#□"
2270#□"
1803#□"
1660#□" =41% of f'c
1320#□" =44% of f'c
980#□" =49% of f'c
937#□"
860#□"
806#□"
720#□"
661#□"
580#□"
1% Vert. Steel
1/4% Spiral
2% Vert. Steel
1/2% Spiral
3% Vert. Steel
3/4% Spiral
4% Vert. Steel
1% Spiral
5% Vert. Steel
1 1/4% Spiral
6% Vert. Steel
1 1/2% Spiral
12-13-33

Fig. 2

COMPARATIVE COLUMN CAPACITIES FOR RODDED AND FOR SPIRALLY REINFORCED COLUMNS

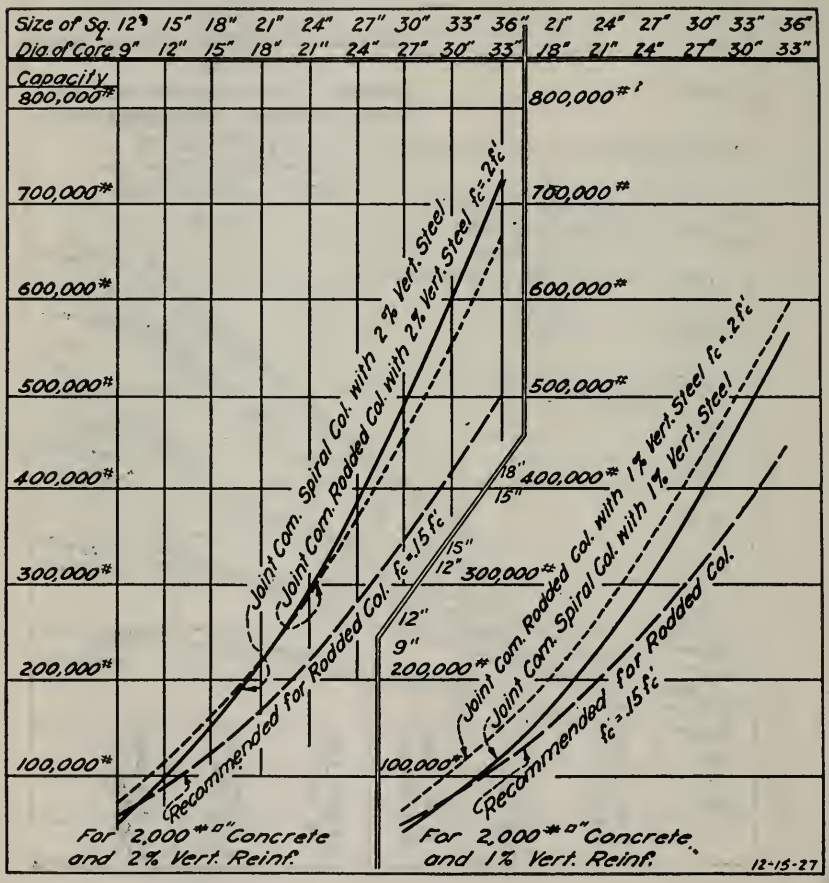

Fig. 3

Appendix B

REGULATIONS FOR FLAT SLABS
(Four-Way System)

By M. Hirschthal, Concrete Engineer, Delaware, Lackawanna & Western Railroad

Moments for flat slabs designed for railroad locomotive loading shall be figured by the theorem of three moments for spans center to center of columns longitudinally for such locomotives as are held standard on the railroad in question. In figuring these moments, such conditions of loading shall be assumed and figured as will give the maximum positive moments on the end spans and on the intermediate spans as well as the maximum negative moment over the support adjacent to the ends and over the intermediate supports. Conditions of loading for maximum sheers shall also be figured.

The distribution of the live load moments shall be dependent on the distance center to center of tracks over which distance the live load may be considered distributed, where platforms need not intervene. That portion of the maximum positive moment included between the center lines of columns shall be considered as resisted by the two longitudinal half bands and the two diagonal bands in inverse proportion to the respective distances of the center of gravity of these bands to the center of live load moment on the panel.

The maximum negative live load moments along the center line of columns transversely as well as the postive moments at the centers of transverse bands shall be figured by the theorem of three moments using the equivalent uniform load for the condition of maximum moment longitudinally, with the condition of one track loaded, two tracks loaded, etc., to determine the various maximum moments transversely.

The moments due to the uniform and concentrated dead loads (train shed or canopy columns, signal bridge supports, etc.) shall then be figured and distributed as indicated. The maximum live load moment plus the dead load moment plus the impact derived by use of the formula $\frac{L.L.M.}{D.L.M. + L.L.M.} \times L.L.M.$, shall be considered the moment to be resisted by the various bands.

For the reduction of the moment due to the shortening of the spans by means of the column design the various moments shall be modified by the coefficient $(1\text{-}C)^2$ where C is the ratio that the diameter of the column capital bears to the span length center to center of columns. The moment on diagonal bands shall then be modified by the relationship between diagonal and direct spans and by the fact that two diagonal bands transfer the stresses at the center of span.

In figuring moments in either direction the amount of end restraint or the lack of it shall be given consideration. In the case of skew or irregular panels, each diagonal shall be considered as resisting the moment of diagonal bands in inverse proportion to the distances center to center of columns of the respective diagonals.

For slabs with drop panels the slab thickness may be assumed as obtained from formula $t_2 = 0.02L\sqrt{w} + C$ where L = span length in feet center to center of columns, w = total uniform load in pounds per sq. ft. and C = fireproofing protection to center of reinforcing steel; t_2 is in inches. The depth of drop panel shall not exceed 1½ times t_2.

For slab without drop panels the thickness may be assumed from $t = 0.026\,L\sqrt{w} = C$.

After the moments and shears have been found the slab thickness may be modified to meet these requirements.

In no case shall the slab thickness be less than $\frac{L}{32}$ for floor slab (nor $\frac{L}{40}$ for roof slabs). Where the dropped panels is used, the length of side or diameter shall not be less than $\frac{L}{3}$ nor greater than $\frac{L}{2}$ where L = span in feet center to center of columns. The column capital shall have a diameter or side of not less than $.2L$ nor more than $.25L$.

The section to be figured for resisting the positive moment in any bands shall not exceed $\frac{L}{2}$ in width nor shall any steel other than that of the band be considered.

For negative moment the section to be considered shall not exceed the periphery of the drop panel, and only such reinforcement which extends 40 diameters beyond the column capital shall be considered as resisting the moment.

The compressive stress in the concrete resisting positive moment shall not exceed $.35\ f'_c$ and that resisting negative moment at the column capital shall not exceed $.40\ f'_c$.

The allowable shearing and bond stresses in flat slab design shall be similar to those in simple slab, but the critical section for such stresses may be taken at a point distant from the column capital equal to the depth of the dropped panel and in the slab at a point at a distance from the dropped panel equal to the depth of slab.

The point of inflection may be assumed as being $0.25\ L$ for slabs with dropped panels and $0.3\ L$ for those without dropped panels. Reinforcement shall be so designed as to carry the bars either side of the point of inflection at least 20 diameters for all bands. At least one-third of the bars used for positive reinforcement shall extend into the dropped panel not less than 40 diameters and preferably beyond the center line of columns. Where there are no dropped panels the bars shall extend at least to within one-eighth of the span center to center of columns.

Appendix C

(3) REPORT ON PROGRESS BEING MADE IN METHODS OF CONCRETE MANUFACTURE

R. A. VanNess, Chairman, Sub-Committee; J. T. Andrews, M. W. Beach, A. C. Irwin, L. W. Skov, P. H. Winchester.

INUNDATION METHOD OF SAND MEASURING

Appendix B of the Report of the Committee on Masonry published in Bulletin 295 gives the fundamentals upon which the inundation method of sand measurement is based and outlines how to proceed in using the inundator. It was there pointed out that by measuring the sand in an inundated condition, a large part of the variation occasioned by the bulking of the sand when measured volumetrically is eliminated. In other words, the bulk of inundated sand is always the same, while, if the sand is measured by volume as in wheelbarrows, the actual amount of sand will vary considerably because of moisture content.

There are certain limitations, however, to the practical use of the inundator that may be noted. Basic proportions for concrete are usually expressed in terms of the dry, rodded aggregate, in order to eliminate errors due to the bulking effect of moisture and measurement of loose aggregate. Such proportions must be corrected to allow for the bulking of the aggregate.

The inundator does not automatically correct for changes in the grading of sand nor for the condition arising when the amount of water of inundation plus that in the coarse aggregate exceeds the specified total amount of water specified per sack of cement.

Tests indicate that a volume of inundated sand contains somewhat less sand than the same volume of dry rodded sand, although it is usual to assume that sand in its inundated condition is equivalent in amount to dry rodded measurement.

The inundation method is limited to the measurement of fine aggregate and, in preparing to use the inundator, it is necessary to first work out the proper proportions, on the basis of dry rodded measurements, that will give the workability desired with the specified amount of water per sack of cement. As an illustration, assume a mix of 1:2½:3½ and a specification of 6¾ gallons of water per sack of cement. This 6¾ gallons will be made up of the water of inundation, the water introduced with the course aggregate and the water supplied by the excess water tank. The water supplied by the inundator may be found as follows:

Dry a sufficient amount of sand to fill a ⅕ cu. ft. measure dry rodded. Weigh this sand. Fill ⅕ cu. ft. measure with water and place it in a pan. Sift sufficient sand into this measure to bring the sand level with the top of the measure. Considerable water will be displaced by the sand and will be caught in the pan. The weight of this water subtracted from the weight of ⅕ cu. ft. of water (12.5-lb.) will give the weight of water required to

inundate ⅕ cu. ft. of sand. Some of the ⅕ cu. ft. of dry rodded sand will be left over and the weight of this remainder of sand compared with the weight of the ⅕ cu. ft. of dry rodded sand will give the percentage of difference between sand in its dry rodded condition and its inundated condition. Assume 8½ pounds of water overflowing into the pan and 6% of the sand left, the volume for which the inundator must be set to produce 2½ cu. ft. of sand and also the amount of water introduced into the mix by the inundator can be computed. Thus the inundator must be set at $(1.06 \times 2.5) = 2.65$ cu. ft. and the water volume equals $2.65\ (12.5 - 8.5)\ 5 = 53$ lb. or 6.36 gallons per sack of cement. There is, therefore, $6.75 - 6.36 = 0.39$ gallons to be supplied by the excess water measuring tank and by water in coarse aggregate. If the coarse aggregate carriers 1 per cent of free water and the weight of a cu. ft. of dry, loose, coarse aggregate is 92 lb. per cu. ft., the coarse aggregate furnishes $\frac{.01 \times 92 \times 3.5}{8.33} = 0.39$ gallons of water per sack of cement. Thus, it is found that no water is required from the excess water measuring tank, but greater amounts of free water may be found in the coarse aggregate. Assuming this free water amounts to 2 per cent, there would be $\frac{.02 \times 92 \times 3.5}{8.33} = 0.78$ gallons of water added per sack of cement and .39 gallons to be withdrawn from the inundator. While the foregoing is an assumed example, it is not as striking as would result with sands of very high moduli used in lean mixes.

Whenever there is a marked change in the grading characteristics of the sand, it is necessary, if accurate control is desired, to redetermine the water of inundation and the ratio of inundation measurement to that of dry rodded.

When the amount of water in the coarse aggregate plus the water of inundation of the fine aggregate exceeds the amount of water that is specified, it is necessary to compensate for the excess water of the inundation.

SIZE OF CONCRETE MIXERS

So far as your Committee has been able to ascertain, no extensive tests have been made to determine the quality of concrete manufactured under similar conditions as affected by changing the size of mixers. Results of questionnaires sent to concrete machinery manufacturers indicate that in their investigations, the size of mixer has little or no relation to the quality of the concrete produced.

Appendix D

(5) SPECIFICATIONS FOR FOUNDATIONS, INCLUDING EXCAVATION, COFFERDAMS, PILING, ETC.

J. J. Yates, Chairman, Sub-Committee; Job Tuthill, J. T. Andrews, M. W. Beach, J. A. Bohland, T. L. Condron, W. T. Davis, J. A. Lahmer, A. N. Laird, Blair Ripley.

Your Committee has confined its work this year to a review and study of specifications for foundations obtained from a number of Railroad Companies.

The Committee has selected certain abstracts from these specifications that are typical of the open well dredging caisson, the pneumatic caisson, and the floating caisson founded on pile foundations, which abstracts are published as information.

OPEN WELL DREDGING CAISSONS

The open well dredging caisson method used by the New York, New Haven & Hartford Railroad in 1916 in the construction of the Thames River Bridge at New London, Connecticut, consisted in the sinking of the wood caisson with reinforced concrete cutting edge to average depths of 96 ft. to 132 ft. below mean low water by means of dredging the mud, clay, loam and shells, in the open wells, within the caissons. After the caissons reached the required depths the wells were completely sealed with concrete.

The dimensions of the cutting edges of the caissons reaching 96 ft. below mean low water were 30 ft. by 94 ft., while those reaching 132 ft. below mean low water were 42 ft. by 99 ft.

Clauses in the specifications applying to this method are as follows:

Building up of Caisson Walls

Open-well caissons shall be built to general dimensions shown upon the plans, and the side walls of the caisson added to as the sinking progresses. The plans for pier caissons show general arrangement and dimensions. The Contractor shall submit detail plans of each caisson for approval by the Engineer.

Cost of Caisson

The materials in the caisson walls shall be paid for at contract unit prices. These unit prices are to include the cost of removal of those portions of the outside caisson walls which are used as temporary cofferdams extending above the river bed and must be removed to the elevations as indicated on the plans.

Caissons to be Watertight

The side walls and dredging well walls of the open well caissons shall be watertight so that the concrete filling between the dredging well walls and the exterior walls can be laid in the dry. Timber used in caissons shall be long leaf Southern yellow pine of "Merchantable" inspection as pro-

vided by "Interstate rules of 1905," and shall be surfaced, framed, fastened, and caulked as shown on plans or required by the Engineer.

Sinking Caissons

Each caisson shall be kept to its proper position throughout sinking and when the sinking is completed the top of the caisson shall not be more than 6 in. out of line in either direction, and not more than 2 in. out of level in length or more than 1 in. in the width of the caisson.

Sinking Weights for Caisson

If additional weight is required during the sinking of the caisson other than the weight furnished by the caisson itself and the concrete and gravel filling placed during sinking, this additional weight shall be supplied and removed by the Contractor as part of his work, without any further compensation than the unit prices paid for the permanent portions of the pier. Ballast for filling the permanent pockets of caissons shall consist of good clean gravel.

Note.—Gravel as specified herein was not used as the filling material, all wells and pockets being filled with concrete throughout.

Control of Sinking

The Contractor must take every precaution to control the sinking of the caisson, keeping same level and plumb throughout the entire process.

Divers

The Contractor shall provide divers and necessary apparatus for proper examination of the sinking as it progresses, the entire cost of which shall be covered by unit prices for excavation. The Engineer may, at his discretion, call for examination by the Contractor's diver.

Depth of Sinking Determined by Engineer

Caissons shall be sunk to an elevation satisfactory to the Engineer. Elevations shown on the plans for the bottoms of the caissons are approximate only, and will be varied in accordance with conditions encountered during the sinking of the caissons, and the caissons may be founded, at the discretion of the Engineer, at higher elevations of base, or at lower elevations of base than that shown on the plans, and in case such variations in the base elevations are made, there is to be no change in the unit prices for the various portions of the completed work.

Water Jets in Caissons

The caissons are to be provided with proper arrangement of water jets to be used in controlling the sinking.

PNEUMATIC CAISSONS

In the construction of the New York Central Railroad's Castleton Cut-off in 1922, over the Hudson River, below Albany, New York, it was necessary to construct two of the three channel piers, supporting the two main channel spans by means of pneumatic caissons.

The area covered by the west channel pier foundation is 80 ft. by 32 ft.

The area covered by the center channel pier foundation is 80 ft. by 35 ft.

The depth below the river of these foundations is 45 to 50 ft.

The following abstracts on pneumatic foundations, including an alternate method for open well dredging, are taken from the New York Central Specifications covering this work:

General

The pneumatic caissons shall be built by the Contractor in accordance with the Railroad Company's drawings, these specifications and the directions of the Engineer. These drawings are general in character and show the nature of the design. The Contractor will make the detail drawings of same and arrange all shaft, piping, locks and other equipment required by the Contractor in connection with his work. Such plans shall be approved by the Engineer before materials are ordered. All details and all equipment shall be in accordance with the best modern practice for work in compressed air. A cofferdam will, in all likelihood, have to be used in connection with the caissons and shall be of an approved design and construction. This cofferdam shall be removed at the completion of the work.

Depth of Foundations

The caissons shall be sunk into bed rock to such depth as the Engineer may direct. The elevations shown on the plans are approximate average elevations. If the Engineer so directs, the excavation may be carried below the cutting edge, or the rock may be left inside the chamber above the cutting edge.

Compliance with Laws

The Contractor shall comply with any and all laws of the State of New York regulating the employment of workmen in compressed air.

Caisson Equipment

Each caisson shall be equipped with one main shaft, not less than 48 in. in diameter together with an air lock of ample capacity; this air lock shall be placed so as to be above the water level at all times. The shaft shall be equipped with elevator hoist and cage. Each caisson shall also be equipped with two horizontal cylindrical man-locks, each of ample capacity to take care of the maximum number of men that will be employed in the caisson. A refuge chamber shall be provided between these locks and the working chamber with capacity equal to the two locks combined; this working chamber shall be provided with the necessary air supply pipe. These locks will be connected with the open air by means of a shaft equipped with stairs or ladders, the top extending at all times above high water level.

A shaft for handling material together with a suitable lock shall be provided for each of the compartments into which the working chamber is divided; this shaft shall be not less than 36 in. in diameter and shall be provided with iron ladders the whole length, so that this shaft may be used by the workmen in case of an emergency.

All shafts shall have hinged bottom doors, each shall hang freely when the shaft is in use and when not in use this door shall hang so as to be almost closed.

There shall be no less than two independent lines of piping connecting the working chamber and the refuge chamber with the regular air supply equipment, and in addition two similar independent lines connecting with the reserve (emergency) air equipment. Each air supply pipe of the working chamber shall be fitted with an automatic check valve. There shall be a similar enclosed check valve, located at some convenient and approved location in each supply line. Each of the caisson compartments shall be equipped with the necessary pipes for blowing and grouting.

Each man-lock shall be equipped with an air gage and clock placed so as to be visible to the lock tender; in addition each man-lock shall have a recording gage which shall automatically record the change in air pressure within any five minutes.

The working chamber, man-locks and shafts shall be equipped with the necessary amount of electric lights, the wiring to be done in the most approved manner, preferably in approved metallic conduits, all fixtures and wirings made safe as to risk of short circuiting and fire.

Telephone shall be installed in the working chamber and man-locks for communication with the outside, also necessary appliances for signaling purposes. Every possible precaution shall be taken against fire, both inside and outside of the working chamber, and the necessary means for fighting a fire shall be installed.

Compressor Plant

The Contractor shall provide two compressor plants, one of which shall be of sufficient capacity to take care of maximum working conditions besides any emergencies that may arise. The other plant shall be held in reserve and shall be of sufficient capacity to maintain the necessary air pressure during an emergency. The plants shall have a separate source of power.

Air in Working Chamber

The working chamber shall be supplied at all times with a sufficient amount of fresh air, and be well ventilated; if necessary in the opinion of the Engineer, air cooling devices must be adopted. Care shall be taken that the air supply taken from the outside shall be absolutely pure and free from smoke or other impurities.

Medical and Hospital Service

The Contractor shall employ a competent physician who has had experience in the treatment of illness caused by compressed air. This physician shall be present at all times when work is carried on in compressed air, so as to promptly render medical assistance when necessary. The physician shall also examine every man to be employed in compressed air and repeat the examination at regular intervals, say once every sixty days. A hospital room shall be provided for by the Contractor in close proximity to the work. Each room shall contain a hospital lock of modern type connected with the compressed air supply and equipped with cots, lights and telephone. Such locks shall be heated and well ventilated. The hospital lock shall be in charge of a competent nurse selected by the physician. This nurse must have had actual experience in handling compressed air illness.

Dressing Rooms

The Contractor shall also supply necessary dressing rooms with benches, lockers, shower baths, etc., for the use of compressed air workers. Such rooms shall be kept at all times in a neat and sanitary condition.

Refreshments

Hot coffee shall be provided for compressed air workers during working hours.

Launching of Caissons

The Contractor may launch the caissons by any approved method, or they may be built in position if desired.

Timber

The timber shall be of long leaf yellow pine, merchantable quality and framed carefully and accurately, all joints having a close fit. All seams

to be caulked must be carefully prepared. All holes for drift bolts shall be ⅛-in. diameter less than the diameter of the bolt. All other bolts shall fit close in the bolt holes of the timber. All seams and joints of the timber exposed to the water or air pressure shall be thoroughly caulked in accordance with the best practice used in shipbuilding yards. All materials and workmanship shall be approved of by the Engineer before launched. If for any reason the caisson springs a leak after launching or if the timbers are exposed to drying in the sun for any length of time before sinking they shall be re-caulked satisfactory to the Engineer.

Sinking of Caisson and Preparation of Foundation

In placing the caisson great care shall be taken in maintaining it in its true position while being sunk; for this purpose the Contractor shall drive substantial guide piles and staging well braced together. Any deviation that may take place during the sinking shall be promptly corrected and all means possible shall be used to bring the caisson back to its correct position. The excavation shall be brought down to bed rock of such quality as in the opinion of the Engineer is sufficient to carry the load imposed upon it. The rock surface shall be leveled or stepped off and benched, or otherwise prepared in such manner as the Engineer may direct. The rock surface shall be thoroughly cleaned and approved by the Engineer before any concrete is placed.

Allowed Variation in Position and Level

When a caisson has been sunk to its permanent location it shall not be more than one foot out of its true position in either direction. If a level plane be drawn through the highest corner of the caisson the opposite corner, diagonally, shall not be more than 6 in. below this plane; the opposite corner on the short side of the caisson not more than 2 in. and the corner opposite on the long side not more than 4 in. below said plane.

Concreting of Working Chamber

When the caisson has been inspected and approved by the Engineer as to its final position, the surface of the rock, etc., the concreting of the working chamber may begin. The concreting shall be done carefully and thoroughly, especially under the cutting edges and the bulk-heads, so as to bring about a perfect bearing of same on the underlying rock. Any voids must be grouted in a manner approved by the Engineer.

CAISSONS

Type of Caissons

The caissons for the center and West river piers shall preferably be of the general type shown on the plans. The East river pier may be constructed in an open cofferdam provided the cofferdam is pumped sufficiently dry to permit the inspection of the rock bed and the desired excavation of the solid rock. Where caissons are used, the Contractor shall make provision for the excavation of material overlying the rock and the clearing and excavation of the solid rock by the use of compressed air. The Contractor may submit plans for another type of caisson which may be substituted for that shown on the plans, if approved by the Engineer. In any event, the Contractor shall submit full detail plans of the caissons for the approval of the Engineer before ordering material or starting work.

Caissons to be Watertight

If material is excavated by the open well dredging method, as specified in Art. 32, the caisson walls shall be made watertight so that the concrete may be deposited in the dry.

Timber in Caissons

Timber used in caissons shall be long leaf yellow pine of "Merchantable Inspection" grade in accordance with the Interstate Rules for grading timber. It shall be surfaced, framed, fastened and caulked as shown on the plans or as directed by the Engineer.

Steel in Caissons

The steel used in the construction of the caissons shall have been made by the open-hearth process and shall conform to the Standard Specifications for Structural Steel for Buildings of the American Society for Testing Materials. The fabrication shall conform to accepted good practice in modern bridge shops. The Contractor shall place his order for fabricated steel with a shop approved by the Engineer.

Sinking Caissons

Each caisson shall be kept in its proper position throughout the sinking and when sinking has been completed the top of the caisson shall be not more than 9 in. out of line in either direction, not more than 6 in. out of level between diagonally opposite corners, not more than 4 in. out of level between opposite corners lengthwise, and not more than 2 in. between opposite corners crosswise.

Sinking Weights for Caissons

If additional weight is required during the sinking of the caisson other than the weight furnished by the caisson itself and the concrete placed during the sinking, such additional weight shall be supplied and removed by the Contractor at his own expense.

Control of Sinking

The Contractor shall take every precaution to control the sinking of the caisson, keeping it level and plumb throughout the entire process.

Divers

The Contractor shall provide divers and necessary apparatus for the proper examination of the sinking as it progresses. The Engineer may, at his discretion, require examination by the Contractor's diver. The cost of diver's services shall be included in the unit prices named in the Contract for Excavation.

Depth of Sinking

The Engineer shall determine when the caissons have been sunk to the proper depth. No increase in the unit prices or in the lump sum prices for the various classes of work will be allowed, should the Engineer require the caissons to be sunk to a greater or less depth than shown on the plans.

Water Jets in Caissons

The Contractor shall provide a satisfactory arrangement of water jets to be used in controlling the sinking.

Obstructions to Sinking

Any obstructions met with during the sinking of the caissons are to be removed by the Contractor at his own expense.

Sealing of Pneumatic Caissons

Pneumatic caissons shall be sealed at the bottom in accordance with directions of the Engineer. Great care shall be taken to secure a thorough bond between the concrete in the working chambers and the rock surface

in the foundation. Steel dowels shall be used if required by the Engineer. All loose and disintegrated rock shall be removed and the solid rock excavated, as required by the Engineer, and the space between the caisson and side face of the rock shall be thoroughly sealed.

Filling Working Chamber

The working chamber shall be filled in such a manner as to eliminate all voids, to the satisfaction of the Engineer.

Payment for Caissons

Caissons and cofferdams, complete in place, for the three main river piers, will be paid for at the lump sum prices named in the contract. These prices will include the removal of the cofferdams after completion of the work and will include common excavation to the solid rock elevations shown on the plans and the concrete from the rock foundation to elevation — 9.5.

FLOATING CAISSONS FOUNDED ON PILE FOUNDATIONS

The approach piers of the Newark Bay Bridge of the Central Railroad Company of New Jersey between Bayonne, N. J., and Elizabeth, N. J., built in 1925, which support the 125 ft. plate girder spans, are of concrete with a protective band of granite within the tidal range, resting on wood piles, cut off about 22 ft. below mean tide.

The method of construction consisted in first dredging the pier area to a level of three feet below the proposed pile cut-offs to allow for the uplift of the earth caused by the driving of the piles, driving the piles, and cutting off to the desired elevations, then floating and sinking on this pile foundation a caisson, consisting of a reinforced concrete bottom with removable wood sides, constructed and launched near the site of the piers.

The average size of reinforced concrete caisson bottom was 45 ft. by 22 ft. 6 in. Each concrete pier rests on a pile foundation of 153 piles.

Clauses in the Specifications for preparing the site, pile-driving, and caisson work are as follows:

DREDGING

General

The dredging will be done by the Company in accordance with Plan ..... also in accordance with Specifications ..... entitled "Specifications for Dredging for new Newark Bay Bridge, situated between Bayonne and Elizabeth, New Jersey."

It is understood that this specification does not form a part of this contract but is furnished in order that the Contractor may have full knowledge of the order and manner in which the dredging will be done.

Inflow

Any inflow that may occur between the time of the completion of the dredging by the Company and the beginning of the pile driving that may in the opinion of the Engineer interfere with the proper placing of the caisson shall be dredged by the Contractor prior to the driving of the piles at the rates named for dredging.

In case of delay or delays by the Contractor resulting in additional dredging being required, the expense for such additional dredging must then be borne by the Contractor.

Disposal of Dredged Material

Dredged material must be disposed of by the Contractor as provided by law.

PILE FOUNDATIONS

General

The Contractor shall submit full details as to the method and apparatus he proposes to use in the driving and cutting off of the piles and shall secure the approval of the Engineer before any work is started.

Piling

Piles may be of either spruce, Douglas fir or other approved timber which will float so that the pile head will rise to the surface when cut off below water.

Piles shall be cut from sound trees, free from defects, injurious ring shakes, large and unsound knots, decay or other defects which may in the opinion of the Engineer affect their strength, durability or proper driving.

Each pile shall be of not less than twelve (12) inches minimum diameter at the cut-off in the work and shall taper uniformly to not less than eight (8) inches diameter at the small end. A line drawn from the center of the butt to the center of the small end shall everywhere fall within the pile.

All measurements must be made under the bark.

Before driving, the bark shall be peeled from all piles.

Pile Driving

Piles shall be driven to a firm bearing satisfactory to the Engineer. No pile shall be less than twenty (20) feet in length in the finished work.

A steam hammer and water jet must be used and the type and weight of the hammer shall be such as to produce the desired results without injury to the pile.

A follower may be used.

Pile tips may be pointed to a four (4) inch square when driving or if the Engineer so requires shall be provided with metal shoe of approved design, to be paid for at the unit price herein provided.

Piles injured in driving or driven out of place must be replaced by others when so directed by the Engineer.

All piles shall be driven true to line and grade.

Any piles that may be driven too low to be cut off at the required grade shall be replaced by another pile.

The Contractor will not be allowed to pull any pile up to the required grade to make it available in the work.

Any pile so damaged in driving as to be, in the opinion of the Engineer, unfit for the place in which it is driven, must be replaced or repaired, as the Engineer may direct.

Any pile, after having been driven, which may be forced up, due to the driving of surrounding piles, shall be redriven to a satisfactory bearing.

Piles must be cut off level to the proper elevations; variations of cut-off exceeding one-quarter (¼) of an inch from the true elevation of cut-off will be cause for the rejection of the pile, unless it can be driven to proper elevation.

Inspection

An inspection of the foundation piles, after having been cut off, will be made by the Company's diver and, if required by the Engineer, again previous to setting the caisson. The Contractor must render assistance to the extent of furnishing the necessary float stages from which the diver may work.

CAISSONS

General

While the Contractor will be afforded full opportunity to suggest methods of constructing the piers, the following is a description of the concrete bottom open caisson method. It is recognized by the parties hereto that inasmuch as the success of this method depends to such an extent upon the skillful handling of the caissons and the providing of the proper and sufficient safeguards, the Contractor is required to assume full responsibility therefor.

It is proposed by this method to construct the caissons on pile and timber ways, from which the caissons will be launched.

After launching they will be towed to the location of the cut-off pile foundations and the piers constructed as herein specified under piers. The wood sides of the caissons will be removed for use in other caissons.

The Company will provide a location south of its existing bridge for the construction of launching ways.

Concrete Bottoms

The concrete bottoms must be constructed in the air and allowed to season at least twenty-one days after the concrete is fully deposited and before launching.

The concrete and metal reinforcement shall conform to requirements specified under concrete.

Wood Sides

The wood sides shall be constructed as indicated on plans ..... or such modification thereof as may be approved by the Engineer.

They shall be constructed of sound lumber in a workmanlike manner, properly caulked and sealed to prevent water coming in contact with the concrete while being deposited or seasoned.

Gates

The caisson shall be provided with gates or valves of an approved design and of sufficient number and capacity to provide for the rapid sinking of the caisson on the piles.

The caisson must be accurately settled on the cut-off piles; variations exceeding two (2) inches from the locations indicated on the plans will not be accepted.

Any caisson inaccurately settled must be refloated and relocated by and at the expense of the Contractor.

PIERS

General

All concrete and stone masonry must be deposited in the air and must conform to the requirements of these specifications for concrete, metal reinforcement and stone masonry.

First Section

After the caisson is launched and brought to the location of the cut-off pile foundation, the first section of concrete must be deposited continuously until completed and allowed to season at least five (5) days before water is permitted to enter.

Second Section

After the expiration of five (5) days from the completion of the first section, the concrete in the second section shall be deposited in one operation.

When the second section is completed, any water that may be in contact with the first section must be pumped out of the caisson and the concrete of the first section permitted to season for an additional period of at least five (5) days.

The concrete of the second section shall season in the air for a period of at least ten (10) days.

Third Section (Granite Faced)

After the concrete of the second section has seasoned for five (5) days, the granite facing and concrete backing may be constructed.

After the completion of facing and backing and pointing of the joints, five (5) days shall be permitted for seasoning before water is allowed to come in contact therewith.

Fourth Section (Upper Shaft)

The upper section or shaft of the pier may be started within five (5) days after completion of the granite faced section, and must be deposited continuously, including the bridge seats, until completed.

NOTE.—A complete bibliography on foundations was published by the American Railway Engineering Association in Volume 19, 1918, Appendix C, page 733-737.

The American Society of Civil Engineers published in Proceedings, May, 1925, a progress report of the special committee to codify present practice on the bearing value of soils for foundations.

An article of interest by J. W. Rollins, Jr., on Foundation Problems for Piscataqua Bridge, Portsmouth, N. H., was published in Transactions of the American Society of Civil Engineers, Volume LXXXVI, 1923, page 443.

A paper entitled "The Science of Foundations; Its Present and Future," by Charles Terzaghi, published in the November, 1927, issue of the Proceedings of The American Society of Civil Engineers, reviews the present state of the science of foundations as related to the bearing power of soils.

Appendix E

(6) STUDY AND REPORT UPON GENERAL PRACTICES FOR WATERPROOFING RAILWAY STRUCTURES (BRIDGES) COLLABORATING WITH COMMITTEE VI, BUILDINGS, AND COMMITTEE XV, IRON AND STEEL STRUCTURES

J. A. Lahmer, Chairman, Sub-Committee; G. E. Boyd, T. L. D. Hadwen, G. M. Johnson, A. R. Ketterson, F. E. Schall, L. W. Skov, R. A. VanNess, P. H. Winchester.

Consideration of this subject has been limited to concrete bridges. A questionnaire was prepared and sent to Class I railroads, 37 of which furnished data. Sixteen others replied that they had very little experience with this class of work, or for other reasons were unable to furnish information which would be useful to the Committee.

This questionnaire and replies are tabulated on annexed sheets. Summary of replies to the various questions is as follows:

(Question 2)

22 railroads substantially follow specifications for waterproofing solid floors of railroad bridges as recommended by Committee XV and adopted by 1927 Convention; mileage 163,000.
11 railroads do not substantially follow these specifications.
4 railroads which replied did not indicate whether or not these specifications are followed.

(Question 3)

19 railroads use Type A.
8 railroads use Type B.
5 railroads use Type C.
2 railroads use Type D.
5 railroads use Type E.
4 railroads use Type F.

(Question 4)

26 railroads use asphalt between layers of membrane.
1 railroad uses coal tar products between layers of membrane.
9 railroads use both between layers of membrane.

(Question 5-A)

7 railroads use brick to protect membrane on horizontal surfaces.
18 railroads use concrete to protect membrane on horizontal surfaces.
15 railroads use asphalt mastic to protect membrane on horizontal surfaces.
7 railroads use asphalt blocks to protect membrane on horizontal surfaces.

(Question 5-B)

9 railroads use brick to protect membrane on sloping or vertical surfaces.
18 railroads use concrete to protect membrane on sloping or vertical surfaces.
5 railroads use asphalt mastic to protect membrane on sloping or vertical surfaces.
1 railroad uses asphalt blocks to protect membrane on sloping or vertical surfaces.
2 railroads use metal plates to protect membrane on sloping or vertical surfaces.
5 railroads do not protect membrane on sloping or vertical surfaces.

(Question 5-C)

7 railroads use copper plates or joints to prevent rupture at joints.
2 railroads use galvanized sheet metal or lead plates to prevent rupture at joints.
11 railroads fold membrane into joint or recess to prevent rupture at joints.
2 railroads lay membrane over pipe which is later withdrawn to prevent rupture at joints.
3 railroads use tar paper, felt or asphalt sheet to prevent rupture at joints.
5 railroads have special design to prevent rupture at joints.
2 railroads have no standard practice to prevent rupture at joints.
3 railroads do not protect against rupture at joints.

In some of the groups in above summary the number of railroads is greater than total number who furnished information because some of them follow more than one practice.

Abstract of Answers to Questionnaire Regarding Waterproofing of Railroad Structures (Bridges)

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?*	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surfaces?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Atchison, Topeka & Santa Fe.....	Yes.	Type "C."	Asphalt.	1½" of thoroughly mixed asphalt mastic.	Extend waterproofing membrane down over back side of abutment and cover as far as possible with mastic. Earth fill will also protect.	Provide regular expansion joint which will meet all conditions.
Atlantic Coast Line.....	No.		Asphalt or coal-tar products on back of concrete structures. One bridge was waterproofed as follows (from bottom up): 1" creosoted boards; 4-ply roofing felt saturated with asphalt; 1½" of asphalt and fine gravel.			
Baltimore & Ohio.....	No; 3-ply membrane.	Type "B."	Both.	1-2-4 concrete protection 3" thick.	Extend membrane over joint.	By slight fold into niche at joint.

*See footnote on page 640.

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?*	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surfaces?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Bessemer & Lake Erie	No.	Have used manufacturers' specification.	Asphalt or according to waterproofing used.	Brick on last structure; concrete previously.	Use care in selecting material that goes against it and in placing of material.	Membrane continued loosely over joints. Joints filled with expansion joint filler. Used on short spans only.
Boston & Maine		Membrane.	Both.	Concrete or tar or asphalt on horizontal surfaces.	Concrete or brick.	Copper expansion joints.
Central of Georgia	No.	Type "E." Cotton fabric omitted. Use 4 layers of asphalt felt and 5 moppings of asphalt.	Asphalt.	Hard burned clay brick with joints filled with hot asphalt.	Waterproofing carried over edges and down back of abutment 12" and protected by hard burned brick.	Folding down in joint.
Central Railroad of New Jersey	Yes.	Type "A."	Asphalt products.	Asphalt paving blocks	Common brick laid flat against membrane, mortar joints.	Make recesses in concrete, fill recess with asphaltic mastic, press membrane in and fill even with asphalt.
Chesapeake & Ohio	Yes.	Type "A."	Asphalt.	Concrete.	Concrete.	Bent copper sheet and asphalt mastic.

*See footnote on page 640.

Abstract of Answers to Questionnaire Regarding Waterproofing of Railroad Structures (Bridges)

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?*	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surfaces?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Chicago, Burlington & Quincy....	Yes.	Type "A."	Asphalt products.	Hand mixed mastic.	Concrete covering, care being taken to avoid tension in membrane.	Lay pipe under membrane at expansion or construction joints and then withdraw it and fold membrane before concrete course is placed. Also use interlocking steel plates at expansion joints and fill joint with elastic cement. Recommend concrete curb or parapet at each expansion joint as water will drain away from joint.
Chicago, Milwaukee & St. Paul...	No. Burlap used instead of cotton fabric.	Type "B" with burlap.	Asphalt.	Concrete.	Concrete.	Two layers of tar paper over joint beneath membrane.
Chicago, Rock Island & Pacific...	Have used various types of waterproofing but believe specifications presented by Committee XV best practice.	Type "A" preferred.	Both.	Hand mixed mastic in past. Will undoubtedly go to precast asphalt brick.	Concrete or brick.	Lay membrane over pipe and withdraw pipe.
Delaware, Lackawanna & Western		Asphalt membrane protection.	Asphalt.	Asphalt block.	Cement plaster or brick.	Special design.

*See footnote on page 640.

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surfaces?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Detroit, Toledo & Ironton.....		Type "A."	Asphalt products.	2" to 4" layer 1:3 cement mortar reinforced with triangular wire mesh in center.	Extend same mortar protection over ends and slopes.	Membrane laid in "V" joint in deck; hollow in membrane filled with elastic cement; mortar protection carried over.
Elgin, Joliet & Eastern.....	Yes; except do not use brick or concrete protection or coal-tar pitch.	Type "E."	Asphalt.	Mostly prepared mastic although have used hand mixed mastic on a few jobs. Specifications permit premolded blocks but have used none.	Round corners of concrete at bridge ends and allow mastic to flow down over the ends.	Have made no special provision to prevent rupture of membrane. Have found layers of felt and asphalt treated cotton fabric will ordinarily stretch enough to prevent rupture over joint.
Grand Trunk Railway System....	Substantially.	Type "A," including concrete priming coat.	Asphalt.	Rolled mastic or pressed asphalt blocks. Rolled mastic is separated from membrane by layers of 12lb. felt. Formerly used reinforced concrete and common brick. Discontinued use brick account crushing and concrete account cracking.	Pour all mastic material into molds thus making slab of required thickness in sizes which can be handled and these are placed and given one mopping of asphalt.	At all expansion joints the waterproofing membrane is lapped to provide sufficient excess material for the maximum expansion and the protection coat either poured continuous over joint or broken at joint, depending on amount of expansion anticipated.

*See footnote on page 640.

Abstract of Answers to Questionnaire Regarding Waterproofing of Railroad Structures (Bridges)

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?*	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surface.?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Great Northern.....	Yes; except differences in specifications for materials.	Now use type "A" on special structures only, such as city subways. Have used on same type of structures types "C" & "E." Ordinary trestle slabs and deck slabs on steel bridges are not waterproofed with membrane, but given thorough mopping of asphalt waterproofing or tar paint.	Asphalt exclusively with membrane system.	Now use concrete material to protect membrane waterproofing. Have used hand mixed mastic and mastic blocks. Concrete material costs less and believe answers purpose equally well.	Membrane at bridge ends protected by extending material same as on plain surfaces.	At expansion joint place sheet of asphalt with about 18″ unmopped to form cleavage between waterproof membrane and concrete structure.
Hocking Valley.....	Yes.	Type "C."	Asphalt mastic.	1½″ asphalt mastic protection. 1″ modified shiplap asphalt protection.	Draw mastic down over end. No protection where block is used.	Used layer of felt.
Illinois Central.....	Yes.	Type "F."	Coal tar.	1½″ mastic (pitch, sand, gravel).	No protection.	No provision except in special cases.
Kansas City Southern.....	Yes.	Type "A," formerly type "C."	Asphalt.	Usually concrete.	Concrete.	Put bend in membrane.

*See footnote on page 640.

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?*	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surfaces?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Lehigh Valley	Substantially.	Type "B."	Asphalt.	Thin hard burned brick; thin hard asphalt paving blocks; steel reinforced cement mortar; brick and asphalt blocks are laid in asphalt or cement mortar and asphalt poured in joints.	Reinforced cement mortar.	Walling copper plate into concrete.
Union Pacific (O-W. R.R. & N.)	Yes; will in future.	5-ply membrane similar to type "E."	Asphalt.	Hand mixed mastic.	Extend it under galvanized or lead flashing plates.	Combination of galvanized sheet metal and lead plates over joint.
Western Pacific	Yes; generally.	Type "A" except roofing felt is substituted for fabric.	Asphalt.	Felt is given heavy coating of hot asphalt.	Felt is turned down on outside of back walls on ballasted floor bridges.	Expansion joints not used as structures requiring waterproofing have not exceeded 30 ft. in length.
Wheeling & Lake Erie	Yes.	Type "B."	Asphalt.	Concrete.	Extend membrane down back and cover upper portion with concrete reinforced with wire mesh.	Fold membrane down into joint.

*See footnote on page 640.

Abstract of Answers to Questionnaire Regarding Waterproofing of Railroad Structures (Bridges)

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Name of Railroad.	Does your Company apply waterproofing in accordance with specifications presented by Committee XV and adopted by the 1927 Convention?	What type of waterproofing mentioned in Sec. 3, Article 13, on page 719, Bulletin 294, do you use? If you do not use either of these types, what is your specification?*	Does your Company use asphalt or coal-tar products?	What is your practice in the protection of membrane waterproofing? (On horizontal surfaces.)	How do you protect membrane at bridge ends on vertical or sloping surfaces?	How do you allow for movement at expansion or construction joints to prevent rupture of membrane?
Canadian National Railways.....	No.		Asphalt.	Hand mixed mastic.	Hand mixed mastic.	Loop membrane into recesses left in concrete at edges of joints.
Canadian Pacific.....	Yes; in general.		Asphalt.	Asphalt mastic.	By a steel plate attached to steel work carried over ballast wall, on which membrane and its protection are laid.	"V"-shaped copper plate.

Type A. Two layers of asphalt-treated cotton fabric and three moppings of asphalt.
Type B. Three layers of asphalt-treated cotton fabric and four moppings of asphalt.
Type C. Two layers of asphalt-treated felt, one middle layer of asphalt-treated cotton fabric, and four moppings of asphalt.
Type D. Two layers of pitch-treated felt, one middle layer of pitch-treated cotton fabric, and four moppings of coal-tar pitch.
Type E. Four layers of asphalt-treated felt, one middle layer of asphalt-treated cotton fabric, and six moppings of asphalt.
Type F. Four layers of pitch-treated felt, one middle layer of pitch-treated cotton fabric, and six moppings of coal-tar pitch.

REPORT OF COMMITTEE X—SIGNALS AND INTERLOCKING

W. M. Post, *Chairman;*
B. T. Anderson,
W. E. Boland,
W. J. Eck,
W. H. Elliott,
G. E. Ellis,
P. M. Gault,
J. V. Hanna,
J. C. Mock,
H. G. Morgan,
F. W. Pfleging, *Vice-Chairman;*
F. P. Patenall,
J. A. Peabody,
A. H. Rudd,
Thos. S. Stevens,
E. G. Stradling,
W. M. Vandersluis,
R. C. White,
F. B. Wiegand,
Leroy Wyant,
Committee.

To the American Railway Engineering Association:

Your Committee on Signals and Interlocking submits report on the following assignments:

(2) Continue study of automatic train control—collaborating with Committee V—Track and Committee XIV—Yards and Terminals (Appendix A).

(3) Continue study on automatic manual and non-operative signals for highway crossing protection, collaborating with Committee IX—Grade Crossings (Appendix B).

(5) Prepare and submit as information a synopsis of the principal current activities of the Signal Section, American Railway Association, supplemented with list and reference by number of adopted specifications, designs and principles of signaling practice (Appendix C).

Action Recommended

1. That the report in Appendix A relating to development in Automatic Train Control since the last report be accepted as information.

2. That the report in Appendix B relating to development in Highway Crossing Protection be accepted as information.

3. That the report in Appendix C, giving a synopsis of the principal activities of the Signal Section, American Railway Association, together with a list of adopted specifications, designs and principles of signaling practice, be accepted as information.

Recommended Outline of Work for the Ensuing Year

(1) Revision of the Manual.

(2) Report developments of Automatic Train Control, collaborating with Train Control Committee, American Railway Association.

(3) Report developments of Automatic Highway Crossing Protection.

(4) Prepare and submit as information a synopsis of the principal current activities of the Signal Section, American Railway Association, supplemented with list and reference by number of adopted specifications, designs and principles of signaling practice.

(5) Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON SIGNALS AND INTERLOCKING,
W. M. POST, *Chairman.*

Appendix A

(2) AUTOMATIC TRAIN CONTROL

G. E. Ellis, Chairman, Sub-Committee; J. A. Peabody, W. M. Vandersluis, R. C. White.

The last report on Train Control was published in Vol. 28, page 300. There have been no important new devices presented since that date, and therefore no additional operating tests have been made. The American Train Control device which had been installed on the Chesapeake & Ohio Railway has been removed and there is now no example of that device in service.

I.C.C. ORDERS

No additional roads have been required to install train control since the last report, but a considerable mileage above that required by the orders of the Commission has been installed or is under construction on several different roads which already had complied with the orders. A number of orders have been issued permitting various roads to operate non-equipped branch line locomotives of their own and tenant lines over short stretches of equipped track, generally less than five miles in length.

In addition to omission of the requirement that required a displacement checking device on certain devices in the reports on the various installations, the Commission has definitely, by formal order, permitted the Chicago, Rock Island & Pacific Railway to remove the displacement detectors from their ramps. There has been no change, however, in the general requirements under which these displacement detectors were first required.

Progress

As of September 1, 1927, the number of roads required at present to make an installation is forty-four under the first order, five having been exempted or have had their time for completion indefinitely postponed. Under the second order, eleven roads have been exempted or have had the time of completion suspended, leaving thirty-six roads which are required to make the installation. Under the first order all but one road have com-

pleted their installations, and work is well under way on that. On the second order, twenty-six roads have finished their installations and work is in progress on the remainder. There have been some minor changes in the mileage involved, and the total now being 7,646 miles of track in place of 7,769 as last reported. The second order totals 7,494 miles of track, although there may be some readjustments which will change this total a small percentage, as well as in the number of locomotives. Exhibit "A" gives the mileage as at last reported for the first and second orders together with the number of locomotives as of September 1, 1927. It will be noted that in some cases all the locomotives required for both orders are included in the first order. These figures have been compiled from the records of the Committee on Automatic Train Control of the American Railway Association.

I.C.C. INSPECTIONS AND APPROVALS

Additional inspections are made of the permanent installations as soon as they are completed and in operation. As of September 1, 1927, 38 inspections have been made on the first order, and 19 on the second order. Inspections have also been made of some of the voluntary installations referred to in a previous paragraph. Reports have been issued by the Commission on 49 inspections. Exhibit B gives an abstract of the exceptions, requirements, recommendations, etc., made in each of the reports issued since the list published in Exhibit C of Volume 28. These have been arranged in the order as issued by the Commission and not according to devices. The first and second orders are grouped separately.

ANALYSIS OF ACCIDENTS

The Committee on Automatic Train Control of the American Railway Association is continuing its study on accidents as reported by the Commission, but the work has not been completed and no information is available at the present time on this subject.

Exhibit A

Road	First Order Track Miles	First Order Locomotives	Second Order Track Miles	Second Order Locomotives
A.T.&S.F.	203.97	87*	145.8	*
†A.C.L.	239.0	55	344.2	70
B.&O.	73.6	136	185.0	120
B.&A.	235.08	232*	250.74	*
B.&M.	203.9	137	Suspended until further order	
B.R.&P.	Exempt		Exempt	
C.R.R.N.J.	65.6	45	49.7	75
‡C.&O.	70.0	86*	55.0	4
C.&A.	229.1	46	Suspended until further order	
C.&E.I.	210.8	165	77.4	33
C.&E.	Exempt		Exempt	
C.&N.W.	298.0	122	414.0	70
C.B.&Q.	139.8	58	104.4	44
C.I.&L.	67.7	32	92.0	18
C.M.&St.P.	216.2	58	206.1	38
C.R.I.&P.	330.8	95	233.7	49
C.St.P.M.&O.	Exempt		Exempt	
C.N.O.&T.P.	235.0	179*	257.7	10
C.C.C.&St.L.	195.8	90*	181.1	*
D.&H.	120.85	66	154.0	100
D.L.&W.	282.0	68	262.86	130
Erie	204.0	104	279.4	60
G.H.&S.A.	50.23	57	120.31	20
G.N.	142.57	38	113.3	24
I.C.	243.6	60	97.5	41
K.C.S.	Suspended until further order		Suspended until further order	
L.V.	175.02	150	484.58	175
L.I.	32.8	104	55.2	160
L.&N.	162.0	48	139.0	42
M.C.	149.0	247*	233.0	*
M.P.	50.0	39	Suspended until further order	
N.Y.C.	553.11	477	704.1	362
N.Y.C.&St.L.	154.85	45	Suspended until further order	
N.Y.N.H.&H.	119.6	60	226.0	178
N. & W.	106.1	48	132.6	44
N.P.	109.6	35	106.0	8§
O.-W.R.R.&N.	86.1	33	Exempt	
Pa.	163.0	152	490.2	443
P.M.	62.4	73*	86.2	*
P.&L.E.	232.3	126	Exempt	
P.C.C.&St.L.	351.5	122	374.77	306
Reading	113.0	50	91.6	80
R.F.&P.	203.2	75	Not included	
St.L.-S.F.	44.4	42	71.0	34
S.P.	100.1	137	125.4	75
Southern	304.22	107*	303.82	*
U.P.	204.0	99	246.0	31
W.J.&S.	112.4	136	Not included	
W.M.	Exempt		Exempt	
Total	7,646.30	4,421	7,493.68	2,844

*Locomotive first and second orders listed under "First Order."
†Includes 2.83 miles double track on R.F.&P. Ry.
‡Orange Branch included in first order.
§In addition to those required for first order.

Exhibit B

(FIRST ORDER)

INSTALLATION: Delaware & Hudson Company.
DEVICE: General Railway Signal Company.
FIRST ORDER: Whitehall to Rouses Point, N. Y.
111.65 miles single track—4.6 miles double track—66 locomotives.
INSPECTED: July 27-August 20, 1927.
I.C.C. REPORT: Decided January 13, 1927 (Sub. No. 23). Opinion 11978.

EXCEPTIONS:

Non-equipped locomotives must not be operated in train stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: as to Maintenance, Tests and Inspections.

Instructions, reports and records relative to tests of locomotive and wayside apparatus, cleaning periods and seals, should be observed; all reports to be made on forms and forwarded to a designated officer. Some defects in maintenance are noted.

The proper relation between locomotive receivers and the rail should be rigidly maintained through the use of accurate gages.

Enginemen should show on all work reports complete information covering all cases of train stop failures.

Careful consideration should be given to locating the cab whistle of the device on locomotives of double cab type, or having it of such volume that it can be distinctly heard by both engineer and fireman.

Headlight generators of 500 watts capacity are to be replaced with adequate capacity.

Installation and maintenance of the track inductor circuits must be such as to protect the integrity of this circuit. Crosses in the wiring of the inductor itself may result in a false clear condition. An instance is given.

Inductors must be so securely maintained in place that dragging equipment cannot displace them.

INSTALLATION: Baltimore & Ohio Railroad.
DEVICE: General Railway Signal Company.
FIRST ORDER: Baltimore, Md., to Washington, D. C.
34.4 mi. double track—2.2 miles four track—136 locomotives.
INSPECTED: Aug. 23-Oct. 1, 1926.
I.C.C. REPORT: Decided January 13, 1927 (Sub. No. 24). Opinion 11979.

EXCEPTIONS:

Relationship between the track inductor and locomotive receiver must be maintained within the margin of safety prescribed by the manufacturer. Instances are given of false clear failures due to this incorrect relationship.

Non-equipped locomotives must not be operated in train stop territory, or those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Reset element must be removed from the pilot beam to a point at which it cannot be operated while the locomotive is in motion.

REQUIREMENTS: as to Inspections, Maintenance and Tests.

Arrival and departure tests should be made of all train stop equipment on all locomotives in train stop territory. A daily report should be made on a proper form and forwarded to a designated officer. Periodic tests of locomotive equipment must be made.

Inspection indicated that locomotive apparatus was not being adequately maintained, and grounds in the locomotive circuits were not being kept at a minimum.

Headlight and cab wiring was found in bad condition on some locomotives.

Loop coupler covering was found to have been damaged which might result in grounds or short circuits.

Specific instructions regarding the cutting out of device are needed, and enginemen should report whenever the device is cut out of service.

A form should be provided for enginemen in reporting failures of the apparatus.

In case of train stop failures on the road, enginemen should show full information on their work reports.

Locomotive receivers should be checked with proper gage on level track.

The cab whistles should be frequently inspected and so maintained to be readily heard by enginemen and firemen.

The indicator pointer and pinion in the brake valve head should be securely attached to the shaft in all cases to prevent the pinion from falling into the actuator housing and interfering with the manual operation of the brake valve.

Locks for the relay housing, reset apparatus and acknowledging contactor should be provided on all engines.

Where signals are line controlled, the track inductor wires should be carried through contact point of the track relay.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

When changes are made, roadway installation should be checked with the circuit plans.

Periodic checks should be made to insure that the inductors are proper height and gage in relation to the rail and free from crosses or grounds.

Closer cooperation between the maintainers of the roadway apparatus and the locomotive equipment is advantageous.

Several indicators showed evidence of having been rubbed by passing train or locomotive equipment.

It is suggested that information of interest to train and enginemen regarding this installation should be included in the current time tables.

Installation:	Southern Railway.
Device:	General Railway Signal Company.
First Order:	Spencer, N. C., to Greenville, S. C. 152.11 mi. double track—107 locomotives both orders.
Inspected:	Sept. 7-30, 1926.
I.C.C. Report:	Decided Nov. 29, 1926 (Sub. No. 25). Opinion 11814.

Exceptions:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Requirements: as to Maintenance, Inspection and Tests.

Arrival and departure tests should be made of all train-stop equipment on all locomotives in train stop territory. A daily report should be made on a proper form and forwarded to a designated officer. Periodic tests of all locomotive equipment must be made.

Inspection indicated that locomotive apparatus was not being adequately maintained, and grounds in the locomotive circuits were not being kept at a minimum.

A form should be provided for enginemen to report failures and irregularities in the operation of the device, and details should be given when necessary to cut out the device.

In case of train stop failure on the road, enginemen should show full information on their work reports.

The cab whistles should be frequently inspected and so maintained to be readily heard by engineman and fireman.

Locomotive receivers should be checked with proper gage on level track.

Failures reported to be due to core sand causing the governor valve of the headlight generator to stick, should be followed up.

The automatic brake valve should be so assembled and maintained that all ports will accurately register when the rotary is moved either manually or automatically.

The indicator pointer and pinion in the brake valve head should be securely attached to the shaft in all cases to prevent the pinion from falling into the actuator housing and interfering with the manual operation of the brake valve.

The double heading cock should be designed and installed so that the train stop apparatus cannot be cut out without also cutting out the air brake system.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

It is suggested that information of interest to train and enginemen regarding this installation should be included in the current time tables.

Other means for fastening inductors to the ties should be employed if the present method proves to be inadequate.

When changes are made, roadway installation should be checked with the circuit plans.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection. Switch boxes should be carefully maintained. Check should be made to see whether a car or locomotive can be placed between switches and crossovers without maximum protection being afforded to main line traffic.

Installation:	New York, Chicago & St. Louis Railroad.
Device:	Union Switch & Signal Company.
First Order:	W. Fort Wayne, Ind., to W. Stony Island Ave., Chicago. 123.25 miles single track—15.8 miles double track—45 locomotives.
Inspected:	October 12-November 9, 1926.
I.C.C. Report:	Decided February 17, 1927 (Sub. No. 26). Opinion 12103.

Exceptions:

Signal and inductor circuits must be entirely separated to avoid crosses which might lead to a false clear condition. In this installation, the signal relay control common is carried through the track inductor winding.

The reset button must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Requirements: as to Maintenance, Inspection and Tests.

The substitution of higher capacity generators should be vigorously followed to a conclusion.

Inspection indicated that locomotive apparatus was not being adequately maintained, and grounds in the locomotive circuits were not being kept at a minimum.

Correction of irregular headlight generator voltage should not be corrected by adjustment features in the relay. These relays should be sealed after their initial installation and should not be changed, unless there is a change in receiver coils or other essential features.

It is suggested that consideration be given to the restoration of an audible warning in the cab.

Non-equipped locomotives must not be operated in train stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Check should be made periodically to insure that the relationship between track inductors and the rail as to height and gage should be maintained within the limits prescribed by the manufacturer; also that the

inductors are free from grounds or crosses. Inductors should be readjusted after any change in rail.

Locomotive receivers should be checked with proper gage on level track.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

When changes are made, roadway installation should be checked with the circuit plans.

INSTALLATION: Lehigh Valley Railroad.
DEVICE: General Railway Signal Company.
FIRST ORDER: Newark, N. J., to Easton, Pa.
0.92 one track—32.34 two track—19.94 three track—12.40 four track—150 locomotives.
INSPECTED: Oct. 20-Nov. 13, 1926.
I.C.C. REPORT: Decided January 18, 1927 (Sub. No. 27). Opinion 12012.

EXCEPTIONS:

Non-equipped locomotives must not be operated in train stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Pusher and other locomotives operated backward in road service, with the current of traffic, must be equipped with the train-stop device for such movements.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Tests for grounds should be included in report forms for roundhouse inspection, which are otherwise adequate.

Thorough and complete tests of the locomotive equipment should be made periodically.

The double heading cock should be designed and installed so that the train stop apparatus cannot be cut out without also cutting out the air brake system.

The automatic brake valve should be so assembled and maintained that all ports will accurately register when the rotary is moved either manually or automatically.

Careful consideration should be given to locating the cab whistle of the device on locomotives of double cab type, or having it of such volume that it can be distinctly heard by both engineer and fireman.

Integrity of locomotive circuits should be adequately protected against crosses, as some crosses will produce false clear operations.

It is not believed that the type of headlight generator used before the installation of the train stop will be inadequate.

Steps should be taken to make sure that all locomotives have electro-pneumatic valve housings so designed that water will not enter from the outside.

Several locomotives were found without seals or locks on mechanism boxes.

Signal maintainers should have written instructions covering their duties as to the inductor and its circuits, and arrangements should be enforced for periodical inspection of roadside apparatus and circuits.

The proper relation between locomotive receivers and the rail should be rigidly maintained through the use of accurate gages.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

The conditions resulting from use of two position signals at certain points in the three position signal system might warrant special consideration.

It is suggested that braking distances at specified locations be checked.

It is suggested that information of interest to train and enginemen regarding this installation should be included in the current time tables.

INSTALLATION: Chicago, Indianapolis & Louisville Ry.
DEVICE: Sprague Safety Control & Signal Corporation.
FIRST ORDER: South Hammond to Monon, Ind.
67.7 miles single track—32 locomotives.
INSPECTED: November 4-29, 1926.
I.C.C. REPORT: Decided February 17, 1927, (Sub. No. 29). Opinion 12102.

EXCEPTIONS:

The railroad is required to complete the full installation of 68 miles referred to in an order of April 6, 1925, requesting a change of location. This requires an extension of 4.4 miles.

Adequate means must be employed to prevent overcharging the capacity reservoir.

The reset button must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Non-equipped locomotives must not be operated in train stop territory, and those with the devise cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Arrival and departure tests should be made of all train stop equipment on all locomotives in train stop territory. A daily report should be made on a proper form and forwarded to a designated officer. Periodic tests of locomotive equipment must be made.

Inspection indicated that locomotive apparatus was not being adequately maintained, and grounds in the locomotive circuits were found.

In cases of train-stop failure on the road, every effort should be made to definitely determine the cause and apply the necessary remedy in each case.

The standard of adjustment of the equipment company of the magnetic receiver on the engine should be insured.

Attention is called to the alternative method of the Sprague Company to insure proper operation of the service application valve in the brake valve head. In the present installation this depends upon the maintenance of the integrity of the connecting pipe from the oil reservoir.

The absence of the choke in the oil reservoir and supply valve whistle would delay the application of the brakes, and the absence of the whistle in itself would result in failure of the brakes to be applied.

Locomotive receivers must be maintained within prescribed limits with respect to the top of the rail.

Storage batteries where employed on the locomotive should be frequently inspected.

A weak spring in the cut out relay on the current supply panel should be giving consideration pending the installation of new generators and the removal of the storage batteries.

Attention is called to cases in which the equalizing reservoir-service reduction choke was almost completely stopped up with white lead.

Track magnets should be tested and instructions followed as to installation, and after each removal of battery, wire or magnet, an inspection should be made to insure that proper connections have been made.

Substantial filler blocks should be provided under track magnets to lessen the danger of dragging equipment catching under them.

Track magnets should be maintained within the prescribed limit with respect to the top of the rail.

It is suggested that dual responsibility of two departments for maintenance of train control should be abandoned, and one officer placed in charge.

INSTALLATION: Erie Railroad.
DEVICE: General Railway Signal Company.
FIRST ORDER: Port Jervis, N. Y., to Susquehanna, Pa.
102 miles two track—104 locomotives.
INSPECTED: Jan. 12-Feb. 16, 1927.
I.C.C. REPORT: Decided April 26, 1927 (Sub. No. 30). Opinion 12268

EXCEPTIONS:

Reset element must be removed from the pilot beam to a point at which it cannot be operated while the locomotive is in motion.

Pusher and other locomotives operated backward in road service, with the current of traffic, must be equipped with the train-stop device for such movements.

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Written instructions regarding the duties of the maintainers of locomotive apparatus should be posted in order that the men will understand the vital importance of maintaining the integrity of the train-stop apparatus.

Thorough and complete tests of the locomotive equipment should be made periodically.

Locomotive receivers should be checked with proper gage on level track.

Integrity of locomotive circuits should be adequately protected against crosses, as some crosses will produce false clear operations.

Generators employed to furnish current should be properly designed to furnish ample current.

Double heading cocks not yet already altered should be so modified that they will cut out the automatic brake valve before they cut out the train stop device.

The automatic brake valve should be so assembled and maintained that all ports will accurately register when the rotary is moved either manually or automatically.

Locomotives which run over one or more divisions before reaching train-stop territory should have the device tested at terminals at the entrance to train-stop territory.

Check should be made periodically to insure that the relationship between track inductor and the rail as to height and gage should be maintained within the limits prescribed by the manufacturer. Also that the inductors are free from grounds or crosses.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

It is suggested that the type of fouling protection employed at crossovers be considered with a view to possibly securing increased protection.

It is suggested that information of interest to train and enginemen regarding this installation should be included in the current time tables.

INSTALLATION: Cincinnati, New Orleans & Texas Pacific Ry.
DEVICE: General Railway Signal Company.
FIRST ORDER: Ludlow to Somerset, Ky.
78.0 single track—78.5 double track—179 locomotives both orders.
INSPECTED: January 17-February 21, 1927.
I.C.C. REPORT: Decided April 25, 1927 (Sub. No. 31). Opinion 12261.

EXCEPTIONS:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Requirements: as to Maintenance, Inspection and Tests.

Arrival and departure tests should be made of all train-stop equipment on all locomotives in train-stop territory. A daily report should be made on a proper form and forwarded to a designated officer. Periodic tests of all locomotive equipment must be made.

Locomotive receivers should be checked with proper gage on level track. Two failures from lack of proper adjustment were noted.

The headlight generators should be carefully checked to ascertain whether the addition of the train-stop device has resulted in overloading them.

The cab whistles should be frequently inspected and so maintained to be readily heard by engineman and fireman.

There is doubt as to hinge pin of contact finger of reset contactor being sufficiently rugged.

Small clearances in electro-pneumatic valve are noted. A failure from this cause was noted.

Seals should be applied to apparatus and record kept.

Attention is called to possibility of crosses in inductor lead wires. The fact that they are in separate grooves is noted.

Requirements as to use of testing equipment at terminals should be enforced.

The test inductors manufactured by the carrier should be carefully checked to make sure that they have the desired values and characteristics.

Installation:	Boston & Maine Railroad.
Device:	Union Switch & Signal Company.
First Order:	West Cambridge to East Deerfield, Mass. 94.6 miles double track—4.9 miles three track—137 locomotives.
Inspected:	January 20-February 25, 1927.
I.C.C. Report:	Decided May 2, 1927 (Sub. No. 32). Opinion 12277.

Exceptions:

The reset cock must be so located or so designed and constructed that the apparatus can not be reset while the locomotive is in motion. The main switch should be sealed and steps taken to prevent the possibility of defeating the purpose of the train stop system by any of the following methods: Depleting the train-stop pressure and acknowledging, shutting down headlight generator and acknowledging, opening main switch and acknowledging, or manipulating the reset cock in conjunction with the double heading cock upon the starting of an automatic brake application.

Requirements: as to Maintenance, Inspection and Tests.

A definite rule should be established to insure the operation of the turbo generator during the entire time an engine is in train-stop territory.

Certain ball check castings should be marked to reduce the possibility of improper installation.

An additional "cut-in loop" should be established at one specified location for further tests of locomotives. Where the automatic cut in feature is installed, which involves reliance upon the human element, it should be supplemented by such additional check as may be practicable.

Recurrent acknowledgment loops should be installed at all one arm distant signals which are stop indication points at braking distance from home signals.

Switch box shunts at crossovers and turnout switches must be so maintained that a red cab signal due to an open switch shall not be released at such distance as to permit an increase of speed of the train sufficient to be dangerous.

Braking distances should be given careful consideration and attention. is called to certain instances.

Arrangements should be made to afford maximum signal and train-stop protection to main track traffic at cross overs with an engine occupying a crossover and fouling both main tracks.

Attention is called to the possibility of lack of proper protection should one of the rails break in insulated track sections installed for annunciator circuits.

The circuits should be arranged to correct a possible improper signal indication at a specified location.

Two interlocking plants should be provided with detector or approach locking or detector bars.

Means should be provided to insure that a red cab signal will be maintained throughout the block in connection with all absolute stop signals.

Attention is called to a discrepancy in the rule stating that the cab signal will change from green to red on passing a distant signal at caution and what may occur in operation should this change occur with the distant signal at caution due to a signal failure.

INSTALLATION: Chesapeake & Ohio Railway.
DEVICE: Union Switch & Signal Company.
FIRST ORDER: Orange to Staunton, Va.
70.0 miles single track—86 locomotives both orders.
INSPECTED: January 20-March 19, 1927.
I.C.C. REPORT: Decided April 26, 1927 (Sub. No. 33). Opinion 12265.

EXCEPTIONS:

None.

COMMENT:

Since certain crosses or grounds in the locomotive wiring of this installation could result in false-clear operations, the integrity of these circuits must be adequately protected. A cross in the wires leading to the inductor winding, or in the winding itself, would result in a false-clear condition of the inductor. For this reason it is necessary that the integrity of this circuit also be adequately protected.

INSTALLATION: New York Central Railroad.
DEVICE: General Railway Signal Company.
FIRST ORDER: Albany to Syracuse, N. Y.
18.23 miles double track—118.0 miles four track—8.93 miles five track—477 locomotives.
INSPECTED: March 15-May 28, 1927.
I.C.C. REPORT: Decided June 27, 1927 (Sub. No. 34). Opinion 12454.

EXCEPTIONS:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Pusher and other locomotives operated backward in road service, with the current of traffic, must be equipped with the train-stop device for such movements.

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Instructions relative to trip and periodic inspections of locomotive equipment, records and seals, should be continued.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

The work of modifying the double heading cocks so as to cut out the engineer's automatic brake valve before the train-stop device should be promptly completed.

The automatic brake valve should be so assembled and maintained that all ports will accurately register when the rotary is moved either manually or automatically.

Locomotives which run over one or more divisions before reaching train-stop territory should have the device tested at terminals at the entrance of train-stop territory.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection.

INSTALLATION: Pittsburgh & Lake Erie Railroad.
DEVICE: Union Switch & Signal Company.
FIRST ORDER: Pittsburgh, Pa., to Youngstown, Ohio.
11.9 miles two track—0.7 miles three track—51.6 miles four track—126 locomotives.
INSPECTED: March 28-April 27, 1927.
I.C.C. REPORT: Decided June 28, 1927 (Sub. No. 35). Opinion 12488.

EXCEPTIONS:

None.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Measures to maintain constant voltage for train-stop system should be promptly taken.

Since certain crosses or grounds in the locomotive wiring of this installation could result in false-clear operations, the integrity of these circuits must be adequately protected at all times.

Locomotive circuits must be so maintained that changes in resistance will not result in failure.

Correction of irregular headlight generator voltage should not be corrected by adjustment features in the relay. These relays should be sealed after their initial installation and should not be changed, unless there is a change in receiver coils or other essential features.

It is important that meters used in testing be calibrated to the same scale.

Portable test sets used on locomotives should be studied to determine whether their values are correct.

Attention is directed to possibility of high resistance in contacts of electro-pneumatic valves.

The improved spring should be substituted for the original spring in the electro-pneumatic valve.

Bells of low resistance should be replaced by those of a higher resistance on locomotives; this is desirable since certain contacts are incorporated within this bell.

Certain braking distances should be checked.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

INSTALLATION: Boston & Albany Railroad.
DEVICE: General Railway Signal Company.
FIRST ORDER: Springfield, Mass., to Rensselaer, N. Y.
0.68 miles one track—68.21 miles two track—32.66 miles three track—232 locomotives both orders.
INSPECTED: April 20-June 10, 1927.
I.C.C. REPORT: Decided July 27, 1927 (Sub. No. 36). Opinion 12572.

EXCEPTIONS:

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Pusher and other locomotives operated backward in road service, with the current of traffic, must be equipped with the train-stop device for such movements.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

The double heading cock should be so designed and installed that the train-stop apparatus cannot be cut out without also cutting out the air brake system.

Integrity of locomotive circuits should be adequately protected against crosses, as some crosses will produce false clear operations.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses. Methods for testing should be adopted that will disclose any short circuits in receiver or inductor coils.

Exhibit B

(SECOND ORDER)

INSTALLATION: Chicago & Eastern Illinois Railway.
DEVICE: Miller Train Control Corporation.
SECOND ORDER: Danville, Ill., to Clinton, Ind.
38.7 miles double track—33 locomotives.
INSPECTED: Dec. 3-22, 1926.
I.C.C. REPORT: Decided March 30, 1927 (Sub. No. 2-2). Opinion 12204.

EXCEPTIONS:

Positive stop valves must be corrected so that they will prevent the release of the brakes until train has been brought to a stop.

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Non-equipped locomotives must not be operated in train stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Locomotives with New York engineer's brake valve must have their equipment corrected so that the required brake pipe reduction will be made.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Arrangements should be made for inspection and test of all engines on arrival at and before departure from inspection and repair point.

Inspection indicated that apparatus was not being properly maintained.

Care should be taken to keep apparatus free from water, especially to avoid freezing.

Enginemen should show on all work reports complete information covering all cases of train-stop failures.

Braking distances should be checked.

Arrangements should be made at crossovers to afford maximum signal protection to main track traffic.

Greater protection would be given if tracks of Nickel Plate at a crossing were equipped with track circuits.

INSTALLATION: Southern Pacific Company.
DEVICE: National Safety Appliance Company.
SECOND ORDER: Tracy to Fresno, Calif.
125.4 miles single track—75 locomotives.
INSPECTED: July 12-27, 1926.
I.C.C. REPORT: Decided November 22, 1926 (Sub. No. 5-2). Opinion 11801.

EXCEPTIONS:

None.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Instructions in effect as to cleaning of locomotive equipment, checking of seals, etc., should be continued.

Efforts should be made to locate cause of every failure.

Unnecessary bends and right angled turns in certain pipes should be eliminated.

Forestalling valves to be properly inspected and tested to insure correct timing.

Consideration should be given to securing greater clearances in the parts of the duplex control valve.

Proper adjustment should be provided for the control valve magnet armatures.

Periodical inspection and test should be made of the magnetic qualities of the track magnet and reports made on a form and sent to a designated officer.

Circuit plans should be checked with roadside installation when changes are made.

Consideration should be given to providing increased fouling protection.

INSTALLATION: Chicago, Burlington & Quincy Railroad.
DEVICE: Sprague Safety Control & Signal Corporation.
SECOND ORDER: Pacific Junction, Ia., to Lincoln, Nebr.
56.2 miles single track—24.1 miles double track—44 locomotives.
INSPECTED: October 19-November 13, 1926.
I.C.C. REPORT: Decided January 6, 1927 (Sub. No. 9-2). Opinion 11951.

EXCEPTIONS:

Adequate means must be applied an all locomotives to prevent overcharging the capacity reservoir.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Higher degree of maintenance will be required.

Care must be used to maintain the headlight generator and lights and the train-control system free from grounds.

Attention is called to the alternative method of the Sprague Company to insure proper operation of the service application valve in the brake valve head. In the present installation this depends upon the maintenance of the integrity of the connecting pipe from the oil reservoir.

It is important to check operation whenever changes are made or new equipment installed.

Track magnets should be tested and instructions followed as to installation, and after each removal of battery, wire or magnet, an inspection should be made to insure that proper connections have been made.

Certain braking distances should be checked.

INSTALLATION: Great Northern Railway.
DEVICE: Sprague Safety Control & Signal Corporation.
SECOND ORDER: New Rockford to Minot, N. D.
104.52 miles single track—4.39 miles double track—24 locomotives.
INSPECTED: August 2-23, 1926.
I.C.C. REPORT: Decided December 28, 1926 (Sub. No. 10-2). Opinion 11887.

EXCEPTIONS:

Adequate means must be applied on all locomotives to prevent overcharging the capacity reservoir.

Train stop reset apparatus which is not installed in accordance with requirements must be relocated.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Arrangement should be made for inspection and test of all engines on arrival at and before departure from inspection and repair point, and a daily report made on suitable form for the purpose and sent to a designated officer.

A form should be provided for enginemen in reporting failures of the apparatus. Enginemen should report in detail whenever necessary to cut out the device.

In case of train stop failures on the road, enginemen should show full information on their work reports.

Care must be used to maintain the headlight generator and lights and the train control system free from grounds.

Attention is called to the alternative method of the Sprague Company to insure proper operation of the service application valve in the brake valve head. In the present installation this depends upon the maintenance of the integrity of the connecting pipe from the oil reservoir.

Location of vent valve manifold under cab floor is such as to possibly permit water to enter.

Certain junction box conditions may make crosses possible.

It is important to check operation whenever changes are made or new equipment installed.

Track magnets should be tested and instructions followed as to installation, and after each removal of battery, wire or magnet, an inspection should be made to insure that proper connections have been made.

Interlocking circuits at crossing of Soo Line should be rearranged to prevent a clear signal being displayed for Great Northern with Soo Line train between home signals.

Consideration should be given to providing increased fouling protection.

INSTALLATION: Northern Pacific Railway.
DEVICE: Sprague Safety Control & Signal Corporation.
SECOND ORDER: Dickinson, N. D., to Glendive, Mont.
106 miles single track—8 locomotives.
INSPECTED: August 27-September 23, 1926.
I.C.C. REPORT: Decided December 28, 1926 (Sub. No. 17-2). Opinion 11888.

EXCEPTIONS:

Adequate means must be applied on all locomotives to prevent overcharging the capacity reservoir.

Train-stop reset apparatus which is not installed in accordance with requirements, must be relocated.

Automatic train-stop protection should be afforded at two locations where track circuits are not carried through.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Attention is called to the alternative method of the Sprague Company to insure proper operation of the service application valve in the brake valve head. In the present installation this depends upon the maintenance of the integrity of the connecting pipe from the oil reservoir.

The absence of the choke in the oil reservoir and supply valve whistle would delay the application of the brakes, and the absence of the whistle in itself would result in failure of the brakes to be applied.

Location of vent valve manifold under cab floor is such as to possibly permit water to enter.

Receivers must be installed and maintained at standard height.

Conditions leading to forestalling at clear signals should be remedied.

Circuits at two locations should be so arranged to protect against improper indications.

Track magnets should be tested and instructions followed as to installations, and after each removal of battery, wire or magnet, an inspection should be made to insure that proper connections have been made.

INSTALLATION: Southern Railway.
DEVICE: General Railway Signal Company.
SECOND ORDER: Greenville, S. C., to Atlanta, Ga.
151.91 miles double track.
INSPECTED: Sept. 7-30, 1926.
I.C.C. REPORT: Decided Nov. 29, 1926 (Sub. No. 25-2). Opinion 11615.

EXCEPTIONS:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Arrival and departure tests should be made of all train-stop equipment on all locomotives in train-stop territory. A daily report should be made on a proper form and forwarded to a designated officer. Periodic tests of all locomotive equipment must be made.

Inspection indicated that locomotive apparatus was not being adequately maintained, and grounds in the locomotive circuits were not being kept at a minimum.

A form should be provided for enginemen to report failures and irregularities in the operation of the device, and details should be given when necessary to cut out the device.

In case of train-stop failure on the road, enginemen should show full information on their work reports.

The cab whistles should be frequently inspected and so maintained to be readily heard by engineman and fireman.

Locomotive receivers should be checked with proper gage on level track.

Failures reported to be due to core sand causing the governor valve of the headlight generator to stick, should be followed up.

The automatic brake valve should be so assembled and maintained that all parts will accurately register when the rotary is moved either manually or automatically.

The indicator pointer and pinion in the brake valve head should be securely attached to the shaft in all cases to prevent the pinion from falling into the actuator housing and interfering with the manual operation of the brake valve.

The double heading cock should be designed and installed so that the train-stop apparatus cannot be cut out without also cutting out the air brake system.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

It is suggested that information of interest to train and engine men regarding this installation should be included in the current time tables.

Other means for fastening inductors to the ties should be employed if the present method proves to be inadequate.

When changes are made, roadway installation should be checked with the circuit plans.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection. Switch boxes should be carefully maintained. Check should be made to see whether a car or locomotive can be placed between switches and crossovers without maximum protection being afforded to main line traffic.

INSTALLATION: Cincinnati, New Orleans & Texas Pacific Ry.
DEVICE: General Railway Signal Company.
SECOND ORDER: Somerset, Ky., to Chattanooga, Tenn.
92.3 miles single track—82.7 miles double track—179 locomotives both orders.
INSPECTED: January 17-February 21, 1927.
I.C.C. REPORT: Decided April 28, 1927 (Sub. No. 31-2). Opinion 12274.

EXCEPTIONS:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

The railroad company is expected to comply with the requirements as set forth in connection with report on installation of first order.

INSTALLATION: Chesapeake & Ohio Railway.
DEVICE: Union Switch & Signal Company.
SECOND ORDER: Staunton to Clifton Forge, Va.
55.0 miles single track—86 locomotives both orders.
INSPECTED: January 20-March 19, 1927.
I.C.C. REPORT: Decided April 26, 1927 (Sub. No. 33-2). Opinion 12267.

EXCEPTIONS:

None.

COMMENT:

Since certain crosses or grounds in the locomotive wiring of this installation could result in false-clear operations, the integrity of these cir-

cuits must be adequately protected. A cross in the wires leading to the inductor winding, or in the winding itself, would result in a false-clear condition of the inductor. For this reason it is necessary that the integrity of this circuit also be adequately protected.

INSTALLATION: New York Central Railroad.
DEVICE: General Railway Signal Company.
SECOND ORDER: Cleveland, Ohio, to Buffalo, N. Y.
0.21 mile one track—8.19 miles two track—3.32 miles three track—168.33 miles four track—0.03 mile five track—0.68 mile six track—362 locomotives.
INSPECTED: April 1-June 10, 1927.
I.C.C. REPORT: Decided July 26, 1927 (Sub. No. 34-2). Opinion 12571.

EXCEPTIONS:

Locomotives operated backward in road service with the current of traffic should be equipped with the train-stop device for such movements.

The reset contactor on Pennsylvania locomotives operated on or over this installation must be so located that the brakes cannot be released after an automatic application until the train has stopped.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Cautionary paragraphs of report of first installation also apply, as follows:

(a) Instructions and records as to inspection and tests.
(b) Integrity of locomotive and inductor circuit.
(c) Means to determine device on through locomotives is in operative condition when entering train-stop territory.

Means should be devised for detecting short circuits in receiver and inductor coils.

The work of modifying the double heading cocks so as to cut out the engineer's automatic brake valve before the train-stop device, should be promptly completed.

The automatic brake valve should be so assembled and maintained that all ports will accurately register when the rotary is moved either manually or automatically.

Repairmen should be instructed as to testing and repairing coils when removed from receivers and when they are replaced, the polarity should be known to be correct. If inherent trouble exists, the receivers should be returned to manufacturers for repairs.

Measures for maintaining constant voltage on U. S. & S. Company apparatus on Pennsylvania Railroad locomotives operating on this territory should be taken. Locomotive circuits must be so maintained that changes in resistances will not result in failure.

Portable test sets used on Pennsylvania Railroad locomotives should be studied to determine whether their values are correct.

Carefully arranged program for inspection of Pennsylvania Railroad locomotives should be made effective.

Circuits at Pennsylvania Railroad interlocking at Erie should be arranged to prevent the clearing of signals on N. Y. C. when a Pennsylvania train is between derails.

Similar arrangements should be made at Ashtabula.

INSTALLATION: Boston & Albany Railroad.
DEVICE: General Railway Signal Company.
SECOND ORDER: Boston to Springfield, Mass.
0.85 mile one track—60.01 miles two track—15.53 miles three track—20.82 miles four track—232 locomotives both orders.
INSPECTED: April 20-June 10, 1927.
I.C.C. REPORT: Decided July 30, 1927 (Sub. No. 36-2).

EXCEPTIONS:

None.

Appendix B

(3) CONTINUE STUDY ON AUTOMATIC MANUAL AND NON-OPERATIVE SIGNALS FOR HIGHWAY CROSSING PROTECTION, COLLABORATING WITH COMMITTEE IX—GRADE CROSSINGS

A. H. Rudd, Chairman, Sub-Committee; T. S. Stevens, J. A. Peabody.

There have been few changes in the highway crossing protection situation in the past year. Some of the most important are as follows:

1. The Signal Section, American Railway Association, revised and finally adopted revision of Requisite 2, previously approved July, 1925, which now reads as follows:

"2. Location

> The railroad standard highway crossing sign and the signal shall be mounted on the same post. Either a signal of the flashing light type or one of the wig-wag type may be used, but both should not be placed on the same post. No lights, markers or signs, other than those provided in the requisites, shall be placed on this post."

2. While recognizing that in most states the type, location and method of operation of the signals are subject to the requirements and approval of the State Commission, it is the opinion of the Committee that no additional protection is afforded to the occupants of automobiles by the addition of bells. This proposition has been very ably covered by the report of F. Horler (Assistant Signaling Engineer, London & North Eastern Railway) to the Institution of Railway Signal Engineers of Great Britain, submitted March, 1927, which states in part:

> "Bell signals have an arresting and penetrating quality of tone but are subject to considerable modifications due to wind. In addition, many heavy road vehicles carry along with them a great deal of opposition noise." Even "if they are made powerful enough to remain audible under all conditions, their range will generally be less than that of visual signals. In fogs or snowstorms the bell would no doubt have the advantage. As supplements to visual signals in special circumstances, bells may have considerable value, but by themselves they are not self-explanatory."

The Committee recognizes the fact that bells to be of use in stopping all classes of automobiles must usually be so loud as to constitute an annoyance, and should not be used for this purpose; but they may be a valuable auxiliary to the visual signals at crossings used by considerable numbers of pedestrians, such as those located near factories and schools. It is suggested that where such bells are provided as auxiliaries, one be installed which in some states is known as the "pedestrian" bell, and is sufficiently loud to warn pedestrians or drivers of horse-drawn vehicles, but is not as loud as the recommended bell and is, therefore, less annoying to people in the vicinity. In short, bells should be considered as an adjunct rather than a requisite and only be provided in exceptional cases.

3. The Ohio Public Utilities Commission has held hearings on the question of uniformity of highway crossing protection, particularly the utility of electric signals, either wig-wags or alternately flashing lights, for the protection of crossings in place of watchmen.

The Illinois Commerce Commission has also held hearings on the proposition of standardizing either on the wig-wag or the alternately flashing lights, and on the location of such warning signals, whether at the side or in the center of the highway. The Pennsylvania and New York Commissions have standardized on the alternately flashing lights.

The California Commission has issued a definite order prescribing that the wig-wag type automatic flagman shall be the type of protection used for highway crossings, and that the banner shall be painted red.

The Board of Railway Commissioners of Canada has established as standard the three-position wig-wag, the third position indicating that the device is out of order.

In Delaware where there is no Public Service Commission, the Highway Department requires that the signals be located in the center of the highway and in several cases has agreed to widen the highway if necessary for this purpose.

In Pennsylvania, the Department of Highways desires the signals at the side of the road, but, under a recently executed agreement, the Public Service Commission will determine the location.

In Illinois the Highway Department desires the signals located at the side of the road, and in New York and New Jersey the Board of Public Utility Commissioners prefers the signals in the center of the street—here again the Highway Department wishes them at the side of the road.

In fact, with the exception of Delaware, the Highway Departments in a number of the states object to obstructions in the middle of the highway.

The executive ruling handed down by the Public Service Commission of Pennsylvania is as follows:

> "The Department of Highways of the Commonwealth of Pennsylvania, The Public Service Commission, and such railroad companies as may become parties hereto, have agreed upon the establishment of a uniform type of warning signals, as follows:
>
> (1) When automatic warning signals are authorized by the Public Service Commission at crossings of state highways with railroads, the railroad companies shall erect a signal on each side of the railroad which, actuated by approaching trains, shall present to the highway traveler the appearance of a horizontally moving red light the direction of which shall reverse alternately. The signals are to be erected and function in accordance with the recommendations of the signal division of the American Railway Association approved July, 1925. The railroad companies affected shall install and maintain the signals, and the Department of Highways shall pay one-half of the cost of installation. If the installation is made under contract, competitive bids will be requested by the railroad companies; otherwise detailed estimates of the cost of installation will be prepared, and copies of such bids or estimates will be attached to the request for the Department of Highways' participation in the cost of installation and shall be approved as to acceptability by the Chief of the Bureau of Accidents of the Public Service Commis-

sion. Upon the completion of the installation a statement of the actual cost will be forwarded, together with the completion report of the work.

(2) Where a full view of these signals is less than 500 feet on account of curvature or grade in the highway, an additional signal, consisting of a continuously yellow flashing light, shall be installed approaching the curve or grade, so as to give advance warning of the curve and the railroad; the Highway Department to erect and maintain such signals, and the railroad company affected to pay one-half of the cost of installation. Copies of bids or estimates of cost will be forwarded and approved as required where installation is made by the railroad companies, and upon completion of the work, certified statements of the actual cost will be forwarded to the railroad companies.

(3) Approaching dangerous curves, due to separation of grade of highway and railroad, where, in the opinion of the Chief of the Bureau of Accidents of the Commission, additional protection is necessary, similar continuously yellow flashing lights shall be installed, under the same conditions, namely, the Department to erect and maintain, and the railroad company affected to pay one-half of the cost of installation.

(4) The Department of Highways shall not permit the erection of any horizontal alternately flashing red lights on the state highways except for the purpose of indicating the approach of trains at such crossings.

(5) The use of the standard disc approach sign shall be continued and additional ones erected as necessary, and the Department of Highways shall recommend to the Township Supervisors the erection of these signs on township highways where they are not now in use, such discs to be paid for by the railroad company and erected and maintained by the local authorities.

The plan would tend to the establishment of uniform protection devices at crossings now wholly unprotected and improvements over devices now in use at others, and subject to the following conditions and reservations is approved. This approval (1) shall not be construed to diminish or in any wise change or transfer the primary responsibility imposed on railroad companies by the Public Service Company law to furnish and maintain service and facilities at and over grade crossings that shall be at all times safe to their patrons, their employes and to the public; nor to affect the duty of the railroads to change the protection measures when necessary or proper for the safety of any or all of said classes of persons; (2) is conditioned upon notice being given to the Chief of the Bureau of Accidents of this Commission of any proposed installation of lights under the arrangement and in sufficient time prior to the proposed installation to enable said Chief to make an investigation or inspection with respect to the crossing conditions and the sufficiency of the devices proposed to be installed."

Substantially all the railroads have become parties to this agreement.

4. In a large number of cases the authorities have permitted the substitution of automatic signals for gates, and in a number of cases have permitted the protection of several crossings by electric signals in place of gates, the signals being operated by a crossing watchman centrally located. Such a method of operation possesses economic advantages, while not carrying with it the danger incident to lowering gates directly in front of or upon approaching automobiles.

Such signals have also been installed on a line where there are no passenger trains, and the entire movement is a shifting proposition, switches being located at three places so arranged that the signals can be operated from either of these places or rendered inoperative at either of the three by trainmen, who are required, before trains or engines use the crossing, to throw on the lights and to extinguish them when the train movement is finished. A bell has been installed for additional warning to the public and as a reminder to the trainmen.

At other locations, where considerable shifting is done and watchmen are on duty at such times, they manually control the highway crossing signals, operating them not only for movements on the main track but for movements on the sidings, restoring the automatic feature when going off duty.

While most of the railroads have recognized the utility of highway crossing signals operated automatically, only a few have developed their manual application to anywhere near the extent possible through the remote control of these signals by a watchman at a central point.

Some installations have been made where there is no highway crossing watchman, but where the approaching train sets the city traffic signals at stop and causes it to display this indication until the train reaches the crossing.

Several combinations have been installed for the joint operation of the city traffic signals by the traffic officers, by railroad watchmen, or by trains. Such joint control is also entirely feasible, utilizing the standard railroad crossing signals instead of the city signals for this purpose.

At Orlando, Fla., signals protecting twenty-three street crossings are controlled from five cabins, the local conditions being such that automatic protection was impracticable. They are operated between the hours of 6:00 A. M. to 10:00 P. M., sixteen hours a day. During the eight hours the signals are inoperative, the lever controlling each set of signals is in the "off duty" position and a flashing yellow light is displayed. The indications are the same as those at street intersections of the city, red for Stop; yellow and a bell for change of indication, and green for Proceed. The bell does not ring when the lever is in the "off duty" position. The city officials agreed to elimination of crossing gates then protecting crossings if the Atlantic Coast Line Railroad would install traffic light signals at crossings of its line and the city streets, and that if the traffic signals conformed to those of the city, police supervision would be given, which was very ably proved when a reckless driver who ran into and destroyed a signal was heavily fined, sentenced to a road term and forced to pay the cost of replacing the signal. They have also fined other drivers for disregarding the signals. However, after the first two or three weeks the signals were in service, no violations have been reported. With such co-operation from the police department, it can be readily seen that the crossings in Orlando are going to be made safe, or could be made safe in any other city. The night or day speed restriction through the city is twenty-five miles per hour.

It is questionable whether it is good policy for the railroads to give a "Go" signal to highway travelers over the crossing with the railroad.

5. The Safety Section of the A.R.A. has suggested that crossing watchmen, provided with red lamps shielded from the railroad, swing these lamps across the highways when a train is approaching, in order that this lamp, under present practice held stationary, might be distinguished from an automobile tail light or some other stationary red light.

Your Committee is very much in favor of this proposition, as such action on the part of the watchman would provide a signal almost identical with our recommended highway crossing signals, namely, have "the appearance of a horizontally swinging red light and/or disc." In our opinion, the more closely we can approximate the standard, the more confusion will be eliminated.

If this were universally done, it seems to us that it might result in many cases in substituting highway crossing signals for the watchman, which signals, as expressed quite recently by a prominent operating official, "do not go to sleep, do not put in a large part of their time talking to their friends and in fact do not wait for the engine whistle to blow."

6. The location of lights on crossing gates, the kind of light to be installed and the method of operating, perhaps by having them swing or give the appearance of swinging, might well be carefully studied in an attempt to standardize in this important matter and improve present conditions.

7. A number of Committees are engaged in this effort at standardization, and there is danger, unless they co-operate, that great confusion will result—among them are: State Railroad Commissions; State Highway Commissions; Safety Section of the American Railway Association; Grade Crossing Protection and Trespassing Committee, Division 1, Operating, American Railway Association; Special Committee on Highway Crossing Protection, Signal Section, American Railway Association; American Railway Engineering Association Committees IX and X; Committee on Municipal Traffic Ordinances and Regulations, National Conference on Street and Highway Safety, appointed by Secretary Hoover, which had a meeting in Washington on December 8, 1927; the American Engineering Standards Committee, whose report on Code on Colors for Traffic Signals has been approved by the three sponsors and on November 15, 1927, was approved as an American Standard; and the American Association of State Highway Officials, which has standardized on the non-luminous signs governing highway traffic, and is one of the sponsors which has approved the report of the American Engineering Standards Committee for luminous signs and signals to be used in connection with highway traffic.

The signs adopted are all yellow with black lettering; the Stop signs are octagonal in shape; the Caution signs triangular, on which are shown words and graphically, curves, street intersections, street crossings, etc.; Information signs are square; the Approach sign to the railroad is the well

known "R.R." with the cross, except that the background is yellow instead of white.

8. Various devices have been submitted, varying from the recommended standards of the American Railway Engineering Association and the American Railway Association, some of which undoubtedly have good points, but if uniformity is ever to be attained, it can only be done by adhering to some standard and the elimination of local variations therefrom. The Signal Section, American Railway Association, requisite provides for a signal giving "the appearance of a horizontally swinging red light and/or disc." This, with the other requisites, except the one cited at the beginning of this report, has been approved by the American Railway Engineering Association and is included in the recommendations of the American Engineering Standards Committee, Sectional Committee for Code on Traffic Signals, which was approved as an American Standard by the main committee November 15, 1927, copy of which is shown in Exhibit A.

In view of the great progress which has thereby been made in standardization, it would appear that it is the duty of the members of this Association to advocate the use of these standards and discourage any variations therefrom.

Exhibit A

CODE OF COLORS AND FORMS FOR TRAFFIC SIGNALS FOR HIGHWAYS AND VEHICLES

Section 1. Purpose and Scope

Rule 10. Purpose

The purpose of this code is to provide a standard of colors and methods, as applied to highway traffic and vehicles, which will promote uniform usage and thus decrease the likelihood of accidents, and conserve human life and limb. The approval of specific signs or glasses, as complying with the specifications herein contained, should be based upon tests made by competent and disinterested organizations having proper facilities and recognized standing, with final appeal to the United States Bureau of Standards.

Note.—To secure the uniform application of this code, enforcing officers are urged to consult the committee which formulated it (or the American Engineering Standards Committee, 29 West Thirty-ninth Street, New York City) regarding matters of interpretation or items of dispute.

Rule 11. Scope

This code is intended to cover the use of luminous* signs and signals in connection with highway traffic, including moving and flashing signals; the use of lights, semaphores, and other signaling devices on vehicles.

*It is intended to cover standards for non-luminous signs in a future addition to this report.

Section 2. Vehicle Lights and Signals

Rule 20. Headlights

(a) Headlights shall be white, amber, yellow, or any intermediate hue. If electric headlights are used, they shall conform to the rules governing the approval of electric headlighting devices for motor vehicles, of the Illuminating Engineering Society (tentative standard of the A.E.S.C. D2).

(b) No red or green lights shall be displayed upon any vehicle so as to be visible from a point directly in front of it.

Rule 21. Tail Lights

Tail lights shall be red, as seen from the rear.

Note.—Red has been adopted on account of its present universal use for this purpose. This use is not considered consistent with the general standardization of colors, and if a change is made in any jurisdiction, yellow is recommended.

Rule 22. Warning Signal Lights

(a) Light signals displayed on a vehicle to indicate the driver's intention to reduce speed or change direction should be yellow. They shall not be red or green.

(b) Non-luminous mechanical signals displayed to indicate the driver's intention to reduce speed or change direction shall consist of a semaphore which can be projected from the left side of the vehicle. It is recommended that the position of the semaphore when projected be limited to the horizontal.

Rule 23. Marker Lights

Marker lights to indicate the dimension limits of bodies or loads should be located as near the upper left front corner as possible and should be yellow and visible from the front and rear.

Section 3. Highway Traffic Signals

General

Rule 30. Significance of Colors

(a) Red shall be used as an indication to stop and for other purposes where required by law.

Note.—The use of red is proper as an indication to stop and to then proceed if conditions are favorable, as, for example, when "stop and proceed" regulations are in effect.

(b) Yellow shall be used as an indication to exercise caution.

Note.—Yellow is appropriate when caution is to be exercised without stopping, as for partial street obstruction, so as to reserve red for a stop signal.

(c) Green shall be used as an indication to proceed.

Rule 31. Significance of Form

Where definite forms of luminous signs or signals are used either alone or in combination with colors to give the indications specified in Rule 30, the following will apply:

(a) Stop shall be indicated by having the greatest dimension horizontal, as with a horizontal string of lights.

Note.—Where the word STOP is used to direct traffic, it should be in red letters arranged horizontally.

(b) Caution shall be indicated by having the greatest dimension at an angle of 45 degrees with the horizontal when an inclined string of lights is used.

(c) Proceed shall be indicated by having the greatest dimension vertical, as with a vertical string of lights.

Note.—Where the word GO is used to direct traffic, it should be in green letters arranged vertically.

Rule 32. Significance of Flashing

Flashing luminous signals shall conform to the use of colors prescribed in Rule 30.

Section 4. Signals at Railroad Grade Crossings

Rule 40. Aspect

An electrically or mechanically operated signal used for the protection of highway traffic at railroad crossings shall present toward the highway when indicating the approach of a train the appearance of a horizontally swinging red light and (or) disk.

Note.—This covers the use of so-called wigwags and of alternately flashing red lights, and the use of these devices should be restricted to the purpose of indicating the approach of a train.

Rule 41. Location

The railroad standard highway crossing sign and the signal shall be mounted on the same post.

Rule 42. Operating Time

Automatic signal devices for indicating the approach of trains shall be so arranged as to indicate for not less than 20 seconds before the arrival at the crossing of the fastest train operated on the track. Local conditions such as three or more tracks, bad approaches, etc., should be allowed for by increasing the operating time, bearing in mind that too long an operation by slow trains is undesirable.

Rule 43. Flashing Light Type

(a) *Height.* The lamps should preferably be not less than 6 feet nor more than 9 feet above the surface of the highway.

(b) *Width.* The two lamps shall be mounted horizontally 2 feet 6 inches centers.

(c) *Flashes.* Lights shall flash alternately. The number of flashes of each light per minute shall be 30 minimum, 45 maximum.

(d) *Hoods.* Lamp units shall be properly hooded.

(e) *Range.* When lamps are operated at normal voltage, the range, on tangent, shall be at least 300 feet on a clear day, with a bright sun at or near the zenith.

(f) *Spread.* The beam spread shall be not less than 3 degrees each side of the axial beam under normal conditions. This beam spread is interpreted to refer to the point at the angle mentioned where the intensity of the beam is 50 per cent of the axial beam under normal conditions.

(g) *Lenses or Roundels.* The size shall be 5⅜ inches minimum, 8⅜ inches maximum.

Rule 44. Wigwag Type

(a) *Length* of stroke is the length of chord which subtends the arc, determined by the center of the disk in its extreme positions, and shall be 2 feet 6 inches.

(b) *Disk.* The disk shall be 20 inches in diameter. A red lens or roundel shall be placed at the center in front of the lamp.

(c) *Number of Cycles.* Movement from one extreme to the other and back constitutes a cycle The number of cycles per minute shall be 30 minimum and 45 maximum.

(d) The lamp, with which the disk shall be equipped, shall be lighted when the disk is swinging.

Rule 45. Approach Signal

Advance warning signals which indicate approach to a railroad crossing, and not the actual approach of a train, shall conform to the provisions of Section 3, Rule 30.

SECTION 5. SPECIFICATIONS FOR COLORS

Rule 50. Definition of Colors

Red, yellow and green as used in this code are intended to mean:

(a) The colors resulting from the transmission of the proper light through the proper glasses and having the characteristics described in Rules 51 and 52.

Rule 51. Qualitative Definition of Colors for Luminous Signals

(a) *Red.* The spectrum of red shall contain both red and orange but not more than a trace of yellow and no green, blue or violet. The most desirable hue is entirely free from yellow which means that the glass does not transmit the yellow light from a sodium flame.

(b) *Yellow.* The spectrum of yellow shall contain red, yellow and green, with but little blue and no violet. The most desirable hue is entirely free from blue and might be designated a light amber.

(c) *Green.* The spectrum of green shall contain yellow, green, blue and violet, with only a trace of red and orange. This hue is known as "admiralty green" and has a bluish tint when observed by daylight.

Rule 52. Quantitative Definition of Colors for Luminous Signals

The colors red, yellow and green shall have the following characteristics:

	Dominant wave-length Millimicrons	*Purity* Per cent	*Integral transmission of glass* Per cent
Red	Not less than 624	Not less than 100	Not less than 10
Yellow	Not less than 592 nor more than 600	Not less than 97	Not less than 24
Green	Not less than 496 nor more than 536	Not less than 45	Not less than 11

These values are determined by the transmission of light from a source at the color temperature of 2,360 degrees K (practically that of the acetylene flame or present type of vacuum tungsten lamp at normal voltage) through the respective glasses. They are based upon spectral transmission measurements and upon computations carried out in accordance with the methods and data described in the Colorimetry Report of the Optical Society of America.

Note. The light and dark limits of the glasses on which the above values are based have the following relative transmissions on the scale of the American Railway Association:

	Light Limit	*Dark Limit*
Red	300	150
Yellow	200	100
Green	250	100

Appendix C

(5) PREPARE AND SUBMIT AS INFORMATION A SYNOPSIS OF THE PRINCIPAL CURRENT ACTIVITIES OF THE SIGNAL SECTION, AMERICAN RAILWAY ASSOCIATION, SUPPLEMENTED WITH LIST AND REFERENCE BY NUMBER OF ADOPTED SPECIFICATIONS, DESIGNS AND PRINCIPLES OF SIGNALING PRACTICE.

W. M. Vandersluis, Chairman, Sub-Committee; H. G. Morgan, Vice-Chairman, Sub-Committee; F. W. Pfleging.

There is given below a synopsis of the principal current activities of the Signal Section, American Railway Association.

Preparation of outlines for use in determining the economics of automatic signaling and interlocking.

Presentation of summaries of results obtained in train operation by signal indication on the Missouri Pacific Railroad and Seaboard Air Line Railway.

A study of the savings effected by remotely controlled switches.

Revision of the present specification covering electro-mechanical interlocking to bring it up to date.

Revision of the present specification covering the installation of an electric interlocking system to bring it up to date.

Preparation of typical circuits for power interlockings.

Development of typical plans and specifications for automatic signal protection at railroad grade crossings, including circuits covering a single track crossing a single track and a single track crossing a double track.

Revision of specifications covering direct current neutral relays, wood trunking and capping and resistors to bring them up to date.

A very comprehensive book on "Signaling" is under way. The printing of Chapter 6, covering direct current relays, has been issued and a large number of copies sold to the various railroads for distribution to interested parties. Chapter 5, covering "Batteries," and Chapter 10, covering "Alternating Current Relays," have been completed and authorization given for printing. These Chapters will be sold at small cost to the railroads, as has been done with Chapter 6.

Chapter 7, "Direct Current Track Circuits," and Chapter 23, "Highway Crossing Protection," are completed and are now under discussion.

In addition, considerable work has been done in the preparation of definitions for technical terms used in signaling.

Standard drawings are prepared each year, covering apparatus used in signaling. This work has continued, not only covering the preparation of new designs, but also revising the old designs where necessary and eliminating drawings wherever found necessary, due to the progress of the art.

There has been a demand for a revision of the table of signal units and values to include train control and car retarder equipment. This has been given consideration, with a view to adopting a comprehensive table.

Train control accounting has received attention and a table has been set up to show the distribution of initial charges and also maintenance and operation charges to the various accounts.

A specification for Portland Cement, as agreed upon by the American Railway Engineering Association and several other Engineering Societies, has been included in the literature, for convenient reference,

Information relative to the development of automatic train control is being kept up to date and included in the literature.

The present signal aspects, indications, and names of indications are being discussed, with a view to arriving at a standard system for semaphore, color light and position light signals.

Requisites covering highway crossing signals have been revised. A monograph on the development of highway crossing protection has been presented.

The Section has various representatives co-operating with other Engineering Societies.

Co-operative work of particular importance has been carried on with the American Engineering Standards Committee on colors for traffic signals.

There follows a list of Specifications by Manual part number, Specification number, description and approval date of those now in effect.

Part No.	*Spec. No.*	*Description of Specification*	*Approval Date*
2	7319	Alternator	May, 1920
3	11221	Portable A.C. Ammeters	Nov., 1921
4	8620	Alternating Current Automatic Block Signal System	Mar., 1921
5	6324	Direct Current Automatic Block Signals—Low Voltage	July, 1924
6	8720	Type "A" Caustic Soda Primary Cells and Renewals	Mar., 1921
8	3313	Gravity Battery Coppers	1913
9	11321	Primary Battery Jar	Nov., 1921
10	3413	Gravity Battery Zincs	1913
11	11622	Cement Concrete Battery Box	Nov., 1922
12	11722	Glass Battery Jar for Storage Cells	Nov., 1922
13	4314	Electrolyte for Lead Type Storage Battery	1914
15	4915	Nickel, Iron, Alkaline Storage Battery	None
17	8820	Lead Type Portable Storage Battery for Signaling	Mar., 1921
18	5316	Composite Type Stationary Storage Battery for Signaling	None
19	5817	Pure Lead Type Stationary Storage Battery for Signaling	1917
20	3513	Annunciator Bells	1913
21	4427	Direct Current Vibrating Highway Crossing Bell	1927
22	13524	Bonding for Track Circuits	July, 1924
24	5416	Aerial Aluminum Cable Steel Reinforced	1916
25	8920	Aerial Braided Cable for 660 Volts or Less	Mar., 1921
26	9020	Rubber Insulated Armored Submarine Cable for 660 Volts or Less	Mar., 1921
27	9220	Armored Submarine Cable for 2200 Volts	Mar., 1921
28	9120	Lead Covered Cable for 660 Volts or Less	Mar., 1921
29	9320	Lead Covered Cable for 2200 Volts	Mar., 1921
30	9420	Underground Braided Cable for 660 Volts or Less	Mar., 1921
31	12623	Cylindrical Dry Cells	Dec., 1923
32	2312	Copper or Tin Plated Channel Pin	1912
36	1111	Portland Cement Concrete	1911
37	6418	Impregnated Fiber Conduit for the Protection of Insulated Wires and Cables	1918
38	5516	Installation of Fiber and Metal Conduit Systems	1916
39	3613	Steel Pipe Conduit	1913

Part No.	Spec. No.	Description of Specification	Approval Date
40	3713	Wrought Iron Pipe Conduit	1913
41	2412	Vitrified Clay Conduit	1912
42	4514	Installation of a Vitrified Clay Conduit System	1914
48	13023	Drawbridge Circuit Controller	Dec., 1923
49	9520	Universal Switch Circuit Controllers	Mar., 1921
50	5015	Crystallized Copper Sulphate	None
51	2512	Wood Crossarms	1912
52	2612	Crossarm Braces and Heel and Toe Bolts	1912
53	2712	Steel Crossarm Pins.	1912
54	2812	Crossarm Through Bolts and Double Arm Bolts	1912
57	1211	Gasoline Engine with Fuel and Water Tanks	1911
58	1323	Hard Fiber	Dec., 1923
61	3813	Fuses	1913
62	9620	Renewable Cartridge Fuses	Mar., 1921
63	2912	Galvanizing for Iron or Steel	1912
64	13324	Motor Gasoline	July, 1924
65	1411	Electric Generator	None
66	5927	Hand Lantern Globes	July, 1927
67	7419	Impedance Bond	May, 1920
69	13123	Direct Curren Indicator	Dec., 1923
70	9720	Alternating Current Indicator or Repeater	Mar., 1921
75	6518	Electric Interlocking	1918
76	6618	Electro-mechanical Interlocking	1918
77	12526	Electro-mechanical Interlocking Machine, S. & F. Miniature Locking	July, 1926
78	13226	Electro-mechanical Interlocking Machine, unit Electric Levers, S. & F. Locking	July, 1926
79	6725	Electro-Pneumatic Interlocking	July, 1925
80	11822	Installation of Mechanical Interlocking system	Nov., 1922
82	7527	Mechanical Interlocking Machine, S. & F. Locking	July, 1927
83	11427	Mechanical Interlocking Machine Style "A" Locking	July, 1927
84	11922	Electric Wiring for Interlocking Plants	Nov., 1922
85	7619	Power Interlocking Machine	May, 1920
88	1611	Gray iron castings	None
89	1711	Malleable iron castings	None
90	1811	Wrought iron bars	None
91	5115	Incandescent Electric Lamps	1915
92	6017	Made ground apparatus for lightning arresters	1917
95	5215	Vacuum gap lightning arresters	1915
96	9920	Electric Lock for interlocking machines	Mar., 1921
97	12724	Time Locks	July, 1924
98	9820	Universal Electric Lock for hand operated switches	Mar., 1921
103	10020	Direct current, motor operated, first range voltage high signal mechanism	Mar., 1921
104	10120	Universal electric motor switch operating and locking mechanism	Mar., 1921
105	1911	Illuminating Oil	None
106	10220	Zero Fahrenheit Lubricating Oil	Mar., 1921
107	10320	45° Below Zero Fahrenheit Lubricating Oil	Mar., 1921
108	4614	Transformer Oil	None
110	12022	Paint and Painting	Nov., 1922
111	7719	Petrolatum for use in impedance bonds	May, 1920
112	6117	Petrolatum Asphaltum to protect insulated wires in trunking	1919

Part No.	Spec. No.	Description of Specification	Approval Date
113	12127	Compensation of pipe line for the operation of mechanical units	July, 1927
114	12227	One inch welded steel pipe	July, 1927
116	12324	One inch wrought iron signal pipe	July, 1924
117	3012	Eastern White Cedar Poles	1912
119	3913	Push buttons used for the operation of bells, annunciators and similar devices	1913
120	4013	Floor Pushes	1913
121	10420	Air-cooled reactor for line and track circuits	Mar., 1921
122	7819	Alternating current relay	May, 1920
123	10520	Tractive Armature Direct Current Neutral Relays	Mar., 1921
129	12824	Time Releases	July, 1924
135	10620	Resistor for line and track circuits	Mar., 1921
136	6918	Signal roundels, lenses and glass slides	1913
144	7919	Alternating Current motor semaphore signal	May, 1920
145	2011	Direct Current Motor Semaphore Signal	1911
146	8019	Electric Color Light Signal	May, 1920
147	8119	Electric Position light signal	May, 1920
152	2111	Machinery Steel	None
153	10720	Switchboard (A. C. Signal System)	Mar., 1921
155	6217	Switchboard material	1917
157	8226	Friction tape for railroad use	July, 1926
158	5616	Rubber insulating tape	1916
164	8319	Single phase, air cooled track transformer	May, 1920
165	8419	Single phase, line transformer, oil immersed self-cooled	May, 1920
166	12422	Concrete trunking, capping and supports	Nov., 1922
167	5716	Capping and grooved trunking	1916
168	8519	Portable direct current volt ammeters	May, 1920
169	11521	Portable A. C. voltmeters	Nov., 1921
175	10820	Copper Bond Wire	Mar., 1921
176	7018	Copper Clad Steel Bonding Wires	1918
177	2211	Galvanized E. B. B. Bonding Wires	1911
179	11020	Wire Joints	Mar., 1921
180	7118	Thirty per cent conductivity, hard drawn copper clad steel line wire	1918
181	3212	Double braided weatherproof galvanized B.B. line wire	1912
182	7218	Double braided weatherproof hard drawn copper line wire	1918
183	4113	Enameled copper magnet wire	1913
184	4714	Galvanized messenger wire	1914
186	11120	Mineral matter, rubber compound insulated signal wire for 660 volts or less	Mar., 1921
191	10920	Electric light, power supply and trolley lines crossing steam and electric railways	Mar., 1921
192	4213	Crossings of wires or cables of telegraph, telephone, signal and other circuits of similar character over steam railroad rights-of-way, tracks or lines of wires of the same classes	1913
193	13425	Electro-Mechanical interlocking machine vertical locking	July, 1925
195	7002	Switch circuit controller shunting circuit resistance test	Sept., 1924

Part No.	Spec. No.	Description of Specification	Approval Date
196	7003	Train shunt resistance test	Sept., 1924
197	13826	Application of electric locks and circuit controllers to mechanical interlocking machines, using Saxby & Farmer locking	July, 1926
202	14026	Preservative treatment of capping and grooved trunking	July, 1926
204	13726	Oil lighted lamps	July, 1926
206	7004	Fouling protection	Mar., 1926

Below is given a list of rules, reports and principles of recommended practice, reference being made to Manual part number, description and approval date.

Part No.	Description of Rules, Reports and Principles	Approval Date
7	Instructions for Installation and Handling of Caustic Soda Batteries	July, 1927
14	Instructions for Installation, Maintenance and Operation of Lead Acid Type Storage Batteries	July, 1924
16	Instructions for Installation, Maintenance and Operation of Nickel, Iron, Alkaline Storage Batteries	July, 1925
23	Requirements for the Protection of Traffic at Movable Bridges	1916
33	Circuit nomenclature and written circuits	1914
34	Direct Current Automatic Block Signaling Circuits	Nov., 1922
35	Clearance Diagram	1911
43	Form of contract for Block Signal and Interlocking work	Dec., 1923
44	Form of contractor's proposal for block signal and interlocking work	Nov., 1921
45	Form of bond to accompany contract for block signal and interlocking work	Nov., 1921
46	Form of invitation to bidders on block signal and interlocking work	July, 1924
47	Conclusions as to methods of control to cause signals to indicate stop in emergencies	Mar., 1921
55	Technical terms used in signaling	July, 1927
56	Derails	July, 1927
59	Forms for Recording Signal Performance	1914
60	Standard forms for reporting material used and labor performed in construction	Nov., 1922
68	Principles of Signal Indications	1912
71	Take siding indicator	Nov., 1921
72	Switch indicators	1916
73	Instructions for maintaining and handling dry cells	July, 1927
74	Instructions for maintenance of gravity cells	1915
81	Requisites for minimizing the effect of lightning on direct current track circuits	July, 1927
86	Interlocking units and values, distribution form 22	Dec., 1923
87	Table of interlocking units and values	July, 1924
93	Requisites for lightning arresters for signaling	1915
94	Requisites for choke coils for signaling	1915
100	Questions and Answers for signal maintainers	Mar., 1921
101	Examination Papers on Signal Maintenance	Nov., 1921
102	Rules for Signal Maintenance	Nov., 1921
109	Overlaps in connection with automatic signal systems	1918
115	Pipe Thread	Nov., 1922

Part No.	Description of Rules, Reports and Principles	Approval Date
118	Information for Calculating Power Supply and Distribution	Nov., 1921
124	Instructions for inspecting and testing alternating current relays and indicators	Dec., 1923
125	Direct Current Relays	1918
126	Instructions for inspecting and testing direct current relays	July, 1927
127	Requisites for minimizing the effect of foreign current on direct current track circuits	July, 1927
128	Rules for the setting of time releases applied to signal or switch apparatus	Mar., 1921
130	Measurement of insulation resistance	July, 1924
131	Direct current track circuit rail and ballast resistance report	Nov., 1922
132	Formula for computing limiting resistances in series with track battery	Nov., 1922
133	Tables of Minimum Limiting Resistance allowable in series with track battery	Nov., 1922
134	Curves for determining minimum limiting resistance allowable in series with track battery for various train shunt resistances and various battery voltages	Nov., 1922
137	Rules governing maintenance of block signals	1914
138	Rules governing maintenance of interlocking plants	1918
139	Rules governing signal foremen	1912
140	Rules governing signal supervisors	1914
141	Table of average service life in years of the important units of the different types of signal installations	Nov., 1922
142	Construction Program for signaling	Nov., 1922
143	Signaling Practice	1912
148	Highway crossing signals	July, 1927
149	Requisites for light signals for day and night indications	Nov., 1921
150	Method of testing first range D. C. upper quadrant motor signal in service	Nov., 1922
151	Signs or markers for conveying instructions to enginemen and recommendations	1918
154	Instructions for installation and operation of switchboards	Mar., 1921
156	Requisite sheet for switchboard material	1917
159	Electric wire and cable terminology	1916
160	Instructions for making shop torque tests at the semaphore shaft of power operated signals	Nov., 1921
161	A. C. track circuit characteristics	July, 1926
162	Instructions for the adjustment, care and operation of A. C. track circuits	Dec., 1923
163	Automatic train control	1914
170	Voltage Ranges for signal work	1912
171	Impregnating compound treatment of non-oil-proof electrical windings	Nov., 1922
172	Impregnating compound treatment of partially oil-proof electrical windings	Nov. 1922
173	Impregnating compound treatment of oil-proof electrical windings	Nov., 1922
174	Varnish treatment of electrical windings	Nov., 1922
178	Wire inspection report	1919
185	Recommended sags for messenger wire	1914
187	Insulation resistance in megohms per mile at 60° Fahrenheit	1919
188	Requisites for minimizing the sweating of relays	July, 1927

Part No.	*Description of Rules, Reports and Principles*	*Approval Date*
189	Tables of wires required for stranded and flexible conductors	1919
190	Instructions for handling insulated wires and cables	July, 1924
194	Signal layout for remote switches	July, 1925
198	Factors which govern in determining the type of interlockings which should be installed	July, 1926
199	Testing electric locking	July, 1926
200	Inspecting and testing mechanical locking of an interlocking machine	July, 1926
201	Resistances of D. C. Relays	July, 1926
203	Example of use of unit value basis	July, 1926
205	Requisites for minimizing the sweating of semaphore signal mechanisms	July, 1927

The number of current standard drawings is so large that reference is made to the index portion of the standard drawing section of the Signal Section Manual, pages 1 to 33, inclusive.

REPORT OF COMMITTE IX—GRADE CROSSINGS

Hadley Baldwin, *Chairman;*
J. Astrue,
O. C. Badger,
F. D. Batchellor,
H. D. Blake,
B. Blum,
J. G. Brennan,
R. E. Chamberlain,
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R. D. Copeland,
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M. V. Holmes,
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F. J. Stimson, *Vice-Chairman;*
R. L. Huntley,
Maro Johnson,
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A. C. Mackenzie,
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J. W. Purdy,
L. J. Riegler,
F. Ringer,
L. P. Rossiter,
E. H. Roth,
T. E. Rust,
H. M. Shepard,
M. D. Thompson,
W. J. Towne,
A. H. Utter,

Committee.

To the American Railway Engineering Association:

Your Committee presents herewith report covering the following subjects assigned to it:

(1) Revision of Manual (Appendix A).

(2) Continue the study of methods for apportioning the cost of highway improvements adjacent to railway rights-of-way: (a) within incorporated limits of municipalities; (b) without incorporated limits of municipalities (Appendix B).

(3) Investigate and report on the comparative merits of various types of grade crossing protection, collaborating with Committee X—Signals and Interlocking (Appendix C).

(4) Continue the study of excessive number of highway grade crossings of railways, with methods for their removal (Appendix D).

(5) Continue the study and report on the economic aspects of grade crossing protection in lieu of grade separation (Appendix E).

(6) Investigate and report on the use of center columns for highway grade separation.

(7) Study and report on various types and locations of approach and warning signs for grade crossings, also the practices in the several states and Federal requirements, with a view to securing uniformity of practice and standards (Appendix C).

(8) Continue the study and report on (a) laws and regulations affecting the apportionment of Federal aid; (b) the proper form and character of division of costs of separation of grades as between the railway, state, county, municipal or other corporation (Appendix F).

The Committee reports progress on Item (5) Continue the study and report on the economic aspects of grade crossing protection in lieu of grade separation, and on (6) investigate and report on the use of center

columns for highway grade separation; but not to such extent as to justify report.

Action Recommended

(1) That the report on standard highway crossing sign be adopted and published in the Manual.

(2) That the report be accepted as information.

(3) That the conclusions of the Committee be adopted and printed in the Manual.

(4) That the report be accepted and that the recommendations be referred to the Board of Direction.

(8) That recommendation of the Committee be approved and referred to the Board of Direction for transmission to the American Railway Association.

Recommendations for Future Work

1. Continue the study and report on the economic aspect of grade crossing protection in lieu of grade crossing elimination.

2. Continue the investigation and report on the use of center columns (either over or under crossings) in connection with highway grade separation.

3. Study and report on proper division between the railways and the public authorities of the cost of grade crossing protection.

4. Evolve a formula which will develop and evaluate the relative benefits to public and railways from:

(a) Grade Crossing Protection,
(b) Elimination of Grade Crossings,
(c) Reduction of Traffic on Highway Grade Crossings.

Respectfully submitted,

The Committee on Grade Crossings,

Hadley Baldwin, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

Maro Johnson, Chairman, Sub-Committee; R. A. Feldes, W. O. Houston.

HIGHWAY CROSSING SIGN

Following the 1927 convention, the Committee on Grade Crossings was instructed by the Board of Direction to give immediate consideration to the highway crossing sign, with a view to having the plan submitted to the membership for letter-ballot, and in event of approval, to endeavor to have it adopted by the railways and specified in orders by public service bodies. Also, to consider placing on the sign an indication showing the number of tracks to be crossed, in accordance with suggestion made at the 1926 convention, and a later communication received from the President of the American Railway Association, in which was cited the practice of the Union Pacific as an example.

At its first meeting, following receipt of above instructions, the Committee gave consideration to the design of the sign, and a plan was prepared and mailed to the membership with the following letter:

"To the Members:

"The Committee on Grade Crossings was instructed to consider a revision of the Highway Crossing Sign, with special reference to providing an additional sign on the post to indicate the number of railroad tracks to be crossed.

"Your comments on this revised Highway Crossing Sign are desired for the guidance of the Committee.

Respectfully,

E. H. Fritch,

Secretary."

Replies received to the above letter numbered 176. They brought out comment on the following features of the sign:

Auxiliary Sign Showing Number of Tracks at Crossing

Fifty-seven members approved the crossbuck sign with auxiliary sign as designed by the Committee.

Fifty members approved the use of the auxiliary sign, but suggested changes in its details or those of the crossbuck sign.

Forty-three members opposed the use of the auxiliary sign.

Twenty-six members were non-committal as to the use of the auxiliary sign.

Those opposed to the auxiliary sign regard it as unnecessary, liable to distract the attention of the motorist, and to lead to legal difficulties.

They are for the most part men of authority on their lines and represent large mileage. The following letter is quoted as covering the views of these members:

"I have noted questionnaire on highway crossing signs sent out by you under date of August 20th, and understand that the question now under consideration is specifically the providing of an additional sign to indicate the number of tracks crossed.

"This question was considered some time ago on this railway and it was the judgment of the interested officers that the use of the additional sign was not desirable. I concur in this judgment for the following reasons:

"(a) There is a question whether the additional sign will add anything to the safety of the motorist. The statement that there are a definite number of tracks to be crossed may lead him to be less cautious than if he is simply informed by sign that he is in dangerous territory.

"(b) If there is no added safety to motorists there is no justification for the additional expense of maintaining sign.

"(c) The sign would be of questionable value unless the statement as to the number of tracks is at all times correct; it would be very easy for the proper revision of the sign to be overlooked when an additional track is added or one or more removed.

"(d) If not maintained to show the correct number of tracks this failure on the part of the railway would be used by damage suit attorneys as evidence of negligence on the part of the railway.

"(e) There is an uncertainty as to whether the sign is designed to state the number of active tracks such as main tracks and switch leads, or whether it is to indicate the total number of tracks. This may be interpreted differently by different railways, adding to the confusion of the motorist.

"(f) There are many locations where tracks of two or more railways are adjacent and a sign erected by one road would furnish information that is correct for that road's own property, but not correct considering the total number of tracks to be crossed.

"(g) If the use of the sign is adopted by A.R.E.A. any railway not using the sign will be placed at a disadvantage in defending suits for damages account crossing accidents.

"It is my judgment as well as the practice on this railway that nothing should be placed in the vicinity of a road crossing that will tend to take the motorist's attention from the fact that he is in dangerous territory. For this reason we have avoided placing advertising signs or other sign boards at railway crossings, except the crossbuck sign and such other signs as the laws of the various states required.

"Where the state law does not require any specific sign we prefer the use of a board bearing the word 'Danger' rather than the board showing the number of tracks."

Crossbuck Sign

Striping the Post

The most frequent suggestion received was that the post be striped. The Committee on Grade Crossing Protection of the American Railway Association has objected to the striping of the post for the reason it may be mistaken by motorist for a crossing gate in the open position. The

convention of the A.R.E.A. in 1927 voted to omit the striping from the post.

Black Border on Blades

Several members objected to painting a black border around the edge of the blades. All signs now shown in Manual have black borders, and the border on the highway crossing sign is in conformity therewith.

(Note pages 457, 460, 462, 488, and following, in the Manual.)

Height of Sign

Several members think the sign is too high. Two members think it not high enough. Some have evidently regarded the dimensions 11 ft. 3 in. showing height of top of post as applying to the center of the sign, as suggestion is made that the sign be lowered 2 ft. 3 in. The height of the center of the sign is 10 ft. above the center of the roadway. To lower it 2 ft. 3 in. would bring lower corner of the blades within 6 ft. of the surface of the highway, where they would interfere with pedestrian traffic. The height of 10 ft. was arrived at after consultation with the Committee on Grade Crossing Protection of the A.R.A. and is in accordance with their recommendation.

Angle of Blades

There are two or three suggestions that the angle of the blades be 60 deg. instead of 50 deg. because the former is easier for the carpenter to lay out. As most signs are made at division or system shops, the Committee does not consider this suggestion of much importance, but likes the appearance of the sign with blades at 50 deg.

Five members, including three Signal Engineers, favor the use of the sign shown on page 396, Volume 27 of the Proceedings, with 4-ft. blades at an angle of 90 deg., as adopted by the Signal Section and this Association for use with flashing light or wigwag signals. When the sign now being revised was adopted, the matter of using the same crossbuck sign with and without automatic signals was discussed with the Chief Engineer of the New York Public Service Commission, who was of the opinion that it is not desirable or advisable to have the two signs alike; that there should be a distinction between the two so there will be no confusion or chance to mistake them, as the absence of a flashing or warning light might be taken by the traveler to indicate no train is approaching.

Other Suggestions

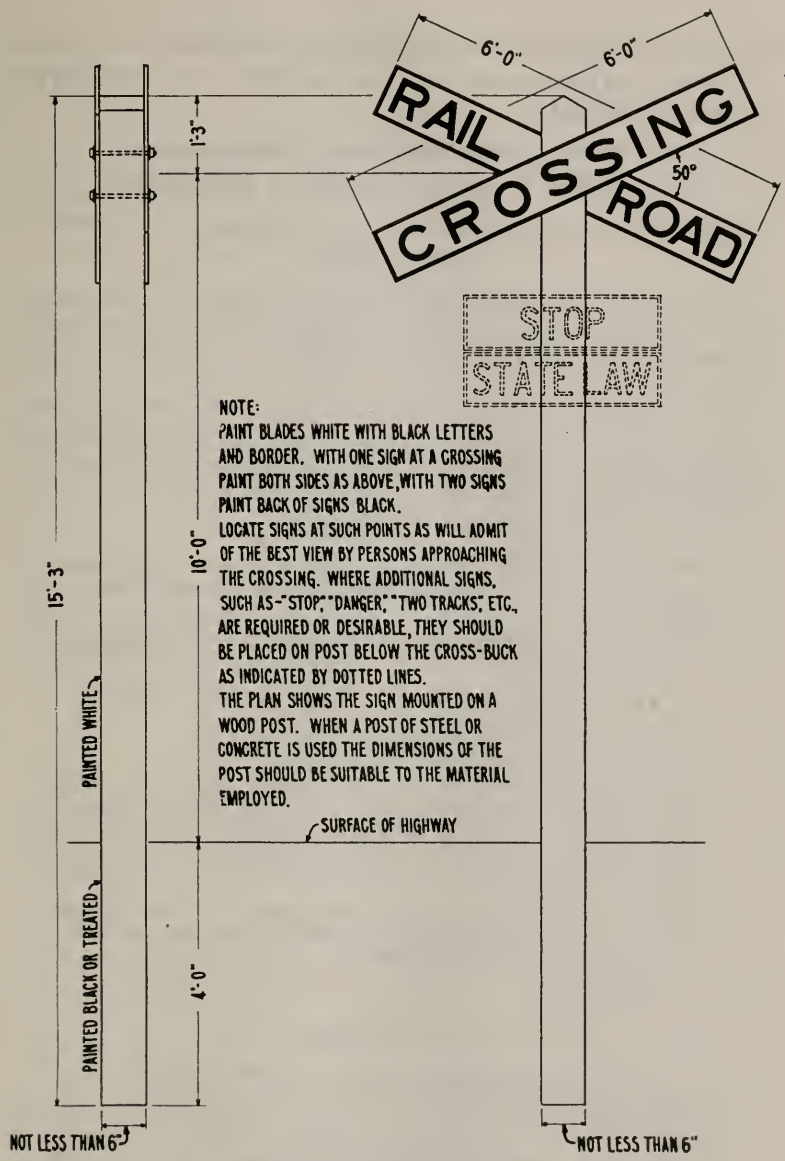
The Committee has accepted suggestions that a post 8 by 8 ft. may be larger than necessary, that the portion of the post in the ground should be creosoted, and that the height of the sign should be measured from the surface of the highway rather than the ground line adjacent to the post.

State Requirements

Several correspondents called attention to state requirements in conflict with this sign. The Committee's instructions are that an effort is to be made to secure the adoption of such sign as is approved by the convention, by states and public regulatory bodies.

Conclusions

After carefully considering all suggestions received, the Committee recommends the adoption of the sign approved at the convention of 1927 with minor modifications above mentioned and omitting specific requirement for an auxiliary sign showing number of tracks at crossing as shown on page 681 of this Bulletin.



Highway Crossing Sign

Appendix B

(2) METHODS FOR APPORTIONING THE COST OF HIGHWAY IMPROVEMENTS ADJACENT TO RAILWAY RIGHT-OF-WAY:

(a) Within Incorporated Limits of Municipalities

(b) Without Incorporated Limits of Municipalities

B. Blum, Chairman, Sub-Committee; R. E. Chamberlain, R. B. Kittredge, R. D. Copeland.

The report of this Sub-Committee last year covered the same subject but was confined to highways outside the incorporated limits of municipalities and this year our work has been confined to improvements in cities and towns.

The work was started by formulating a letter to the chief tax officers of some 14 of the larger railways of the United States, which included a questionnaire as to existing practices in the various communities along their lines so that the facts would be approximately developed.

The following questions were asked in the letter:

1. What in your opinion would be a fair method of apportioning the cost of street or highway improvements adjacent to railway property?
2. What in your opinion are unfair methods of apportioning the cost of such improvements? Are they general, or to what locality are they confined?
3. Are there any municipalities on your line that assess railways for road improvements not abutting the right-of-way?
   (a) If so, to what extent and on what basis?
   (b) What is your opinion of that method?
4. Is it the general tendency in your territory to pay for street improvements such as grading and paving through direct assessments against the property affected or through other means, such as bond issues, general tax fund or other means?
5. Have you any cases where repaving has been directly assessed against the railways?
6. To what extent has your road contributed to the cost of highway or street improvements through municipalities by direct assessment for property benefited?
   (a) Number.....
   (b) Cost $.....

Replies were received from the following:

Great Northern Railway, James T. Maher, Right-of-Way, Land and Tax Commissioner.

Illinois Central Railroad, L. H. Bond, Engineer Maintenance of Way.

New York, New Haven & Hartford Railroad, A. A. Maxwell, Commissioner.

Northern Pacific Railway Company, M. T. Sanders, Tax Commissioner.

Southern Pacific Company—Pacific Lines, Guy V. Shoup, General Solicitor.

Southern Railway System, John B. Hyde, Solicitor.

Union Pacific System, H. C. Mann, Assistant Chief Engineer, System.

The replies from these representative railways were in general quite complete and show the existing trend of charging highway improvements against railway property. The answers to the several questions propounded were given in such form that it did not seem practical to quote directly each one in tabular form but we are summarizing the replies for each question and formulated composite answers as follows:

1. There is a general agreement that assessments for street or highway improvements should be in proportion to benefits received. There is also a general agreement that the benefits to non-operating railway land from improvements are the same as to similarly located private property. There is also agreement that the benefits to be derived from improvements adjacent to station grounds is greater than those adjacent to right-of-way for roadway only. One carrier takes the position that right-of-way should not be assessed for any part of the cost of street or highway or other public improvements, due to the fact that it is not benefited by such improvements and is also devoted in perpetuity to a public use. One correspondent states that in general the theory of the courts has been that although the paving may be of no benefit to the railway property in view of the present use being made of the property, yet the property might be devoted to some other use respecting which the paving would be of value. Louisville & Nashville R. R. Co. vs. Barber Asphalt Co., 197 U. S. 430, is cited as a leading case.

2. The front-foot rule is cited as an unfair basis, as it generally results in railways standing one-half the cost irrespective of the areas involved or benefits received.

Another unfair method is to require the railway companies to bear the entire expense across the right-of-way when the balance of the improvement is paid from general tax funds.

3. In some sections of the country it is common practice to assess railways for road improvements not abutting the right-of-way. This has been done through the so-called Zone method. There does not seem to be much objection to this method if carried out consistently. Where such assessments have been made in State of New York, the court has held them unlawful.

4. The general tendency is to pay for improvements by direct assessments against the property affected. In a number of cases street and alley intersections are paid from the general tax funds and in a few cases the entire cost is paid from general tax or bond issues.

5. Most replies indicate that repaving cost is paid for in the same manner as the original paving, but some exceptions are noted as in the

case of communities served by the New York, New Haven & Hartford Railroad and other cities where the charter provides for the city to maintain pavements.

6. The average amount of assessments for highway improvements for those roads reporting has been approximately $25 per year per mile of road operated. The number of assessments has varied from one to three per hundred miles of road operated but the majority of reporting lines did not have this figure available.

This report is submitted for information. The Committee recommends that further study on this subject be discontinued.

Appendix C

(3) COMPARATIVE MERITS OF VARIOUS TYPES OF GRADE CROSSING PROTECTION, COLLABORATING WITH COMMITTEE X—SIGNALS AND INTERLOCKING

(7) VARIOUS TYPES AND LOCATIONS OF APPROACH AND WARNING SIGNALS FOR GRADE CROSSINGS, ALSO THE PRACTICES IN THE SEVERAL STATES AND FEDERAL REQUIREMENTS, WITH A VIEW TO SECURING UNIFORMITY OF PRACTICE AND STANDARDS

F. D. Batchellor, Chairman, Sub-Committee; H. W. Fenno, W. E. Colladay, A. C. Mackenzie, H. M. Shepard, M. V. Holmes.

These subjects are so closely allied that we have made a study of them as one subject.

An examination of the annual reports sent to the Interstate Commerce Commission by the railways shows that there were 1457 more grade crossings on December 31, 1926, than on December 31, 1925, this in spite of the fact that 1254 crossings were actually eliminated during 1926.

There are four types of crossing protection as reported to the Commission. These are gates, watchmen, signals and fixed signs.

Below is statement showing the relative number of each type, December 31, 1925, as compared with December 31, 1926.

Kind of Protection	*1925*	*1926*	*Increase*	*Decrease*
Gates	6,386	6,170	.....	216
Watchmen	7,935	7,765	.....	170
Signals	12,964	13,992	1,028	...
Fixed Signs	202,348	202,620	272	...
Sub-Total	229,633	230,547	914	...
Otherwise Unprotected	4,068	4,611	543	...
	233,701	235,158	1,457	...

It will be noted from this statement that the number of crossings protected by signals is gaining, while the use of gates and watchmen is decreasing.

Table 1 shows the type and per cent of crossings protected with each type of protection on various railways.

As reported last year, we believe that the signal type of protection is the best when protection is needed and that this is being recognized by the railways and government authorities.

In order to show what progress has been made in reducing accidents at highway grade crossings the following tables are given for the years 1925 and 1926:

TABLE 1—DATA REGARDING PROTECTED AND UNPROTECTED HIGHWAY GRADE CROSSINGS

		HIGHWAY GRADE CROSSINGS													
		Protected by Automatic Signals						Manually Operated Protection		Total Protected Crossings		Crossings Without Protection		Number of Gates or Watchmen Replaced by Automatic Signals	Recommended practice as to Equipment of all Automatic Signals at Highway Grade Crossings with Pilot or Marker Lights as an Advance Warning of Crossing.
		Flash Light		Wig-Wag		Warning Bell									
NAME	Miles Operated	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent		
1. A.T.& S.F.	12,068	None	-	759	6.7	355	3.2	82	0.7	1196	10.6	10,117	89.4		No marker necessary
2. B.& O.	5,196	268	5.6	None	-	191	4.0	185	3.8	644	13.4	4,173	86.6	(50 men (3 gates	Reflex or yellow light on standard of signal.
3. B.& M.	2,357	10	0.5	193	10.5	129	7.0	480	26.0	812	44.0	1,032	56.0	60 men	New York State standard
4. C. Nat. Ry.	22,117	139	0.8	198	1.1	280	1.6	248	1.4	865	4.9	16,609	95.1	65	Now under consideration
5. C.& N.W.	8,462	2	-	386	4.1	263	2.8	296	3.1	947	10.0	8,579	90.0	(113 gates (in 3 years	Yellow reflex signal
6. C.B. & Q.	9,397	22	0.2	244	2.4	82	0.8	197	2.0	545	5.4	9,579	94.6	10	Only when in center of street
7. C.H.I.& P.	8,039	176	2.2	5	0.1	107	1.3	317	3.9	605	7.5	7,426	92.5		Yellow light marker
8. C.C.C.& St.L.	2,187	145	5.3	36	1.3	186	6.8	129	4.7	496	18.1	2,236	81.9	42	Only when in center of road Yellow reflex on signal.
9. D.L.& W.	993	157	16.1	56	5.7	88	9.0	297	30.4	598	61.2	380	38.8	-	New York State standard
10. Erie	2,447	134	5.1	152	5.8	263	10.0	300	11.4	849	32.3	1,775	67.7	12	White reflex center only
11. I.C.	6,873	82	12	155	2.2	237	3.3	94	1.3	568	8.0	6,573	92.0	31	Favors Reflex Marker.
12. L.& N.	5,044	8	0.2	283	6.2	56	1.2	82	1.8	429	9.4	4,155	90.6	1	No marker lights
13. L.H.R.	1,662	101	4.2	68	2.8	93	3.9	232	9.6	494	20.5	1,947	79.5	36	No marker on sides Two Yellow Lights Center
14. M.P.	7,338	1	-	181	4.3	188	4.4	71	1.7	441	10.4	3,800	89.6	-	Marker for center
15. N.Y.C. (East)	3,445	156	6.1	5	.2	329	13.0	225	8.9	715	28.2	1,826	71.8	45	New York State Standard
16. P.R.R.	20,505	494	3.8	35	0.3	774	5.9	805	6.2	2,108	16.2	10,914	83.8	(144 Men (19 gates	
17. St.L.& S.F.	4,990	None	-	43	0.7	125	2.1	145	2.4	313	5.2	5,698	94.8	None	No marker lights
18. U.P.	9,577	1	-	324	-	154	-	36	-	515	-	-	-	None	No marker lights
TOTAL (Omitting U.P.)	113,131	1895	1.7	2,799	2.6	3,746	3.4	4,185	3.0	12,625	11.5	96,789	88.5		

Grade Crossing Accidents According to Type of Protection

	Number Accidents		Persons Killed		Persons Injured	
Kind of Protection	*1925*	*1926*	*1925*	*1926*	*1925*	*1926*
Gates	210	227	115	100	143	175
Watchmen	568	603	164	195	734	718
Signals	777	884	392	478	867	999
Fixed Signs	3897	4148	1535	1718	4811	5099
	5452	5862	2206	2491	6555	6991

Number Deaths and Injuries According to Type of Conveyance

	Killed		Injured	
Kind of Protection	*1925*	*1926*	*1925*	*1926*
Motor propelled	1797	2080	5938	6371
Animal drawn	62	49	155	126
Pedestrians	299	300	273	261
Miscellaneous	48	62	189	233
	2206	2491	6555	6991

These tables show that there were 285 more persons killed and 436 more persons injured in 1926 than in 1925. This would indicate on the face of it that no progress was being made in reducing accidents at crossings, but an examination of the number of motor vehicles registered shows that on December 31, 1925, there were 19,954,357, while on December 31, 1926, there were 22,046,957 registered, or an increase of 2,092,600 motor vehicles.

This shows that a material improvement has been made, but there are still too many accidents at crossings due very largely to carelessness on the part of drivers.

The number of accidents at protected crossings indicates that the public are not taking advantage as fully as they should of the additional protection afforded.

To overcome this the public should be educated as to the various types of protection such as has been done by some railways by issuing pamphlets and advertising in the newspapers.

Where grade crossing protection is necessary there should be a uniform type of signal which would be recognized by the public in any part of the country. Fig. 1 shows the type of flashlight or wigwag signal which we recommend. Where these are used they should replace the standard crossbuck crossing sign.

Fig. 2 shows the location which we recommend for these signals. Where practicable they should be placed in the center of the highway.

Table 2 is a tabulation of the practices in the various states showing the extent to which approach and warnings sign are used.

The most noticeable and encouraging feature of this statement is that 37 states now use the warning signs recommended and adopted by the American Association of State Highway Officials, although some of them do not use the yellow background. Eight states require railways to bear the cost of installation of warning signs and five states require the railways to maintain them.

We recommend that advance warning signs should be placed at important crossings, as it is desirable that motorists receive advance information that they are approaching a railway crossing in time to bring their cars under control.

Where required by law or regulation, the stop sign should also be used.

The advance warning signs and stop sign are shown in Fig. 3. The location of these signs is shown in Fig. 4.

Conclusion

We recommend that Fig. 1, showing flashlight or wigwag signal, and Fig. 2, showing the location of signal, be adopted as recommended practice and that they be placed in the Manual.

We recommend that the advance warning signs and stop sign, Fig. 3, and the location of these signs, Fig. 4, which have already been adopted by the American Association of Highway Officials, be approved as recommended practice.

Table 2—Statement of Advance Warning Signs at Highway Crossings

States	Approach Signs Required by Law	Cost of Installation Borne by	Cost of Maintenance Borne by	Kind of Sign	Location	Remarks
Alabama						No reply.
Arizona						No reply.
Arkansas	Yes			U. S. Std.	300′	
California						No reply.
Colorado				U. S. Std.		
Connecticut	Yes	Railway	Railway	U. S. Std.		White instead of yellow background.
Delaware						No reply.
Florida	Yes			U. S. Std.	250′	Also red reflector.
Georgia				U. S. Std.		
Idaho	No			U. S. Std.	500′	
Illinois	Yes	State	State	W-1 U. S. Std.	300′	White instead of yellow background.
				W-1		Ry. to place "Stop" sign where ordered.
Indiana	Yes	Railway	Counties	U. S. Std.	300′	White instead of yellow background where R. R. has more than 1 track "Multiple Crossing."
Iowa	No			U. S. Std.		
Kansas	No			U. S. Std.	400′	
Kentucky	No			U. S. Std.	350′	"Stop" sign 25 ft. from track required by law at dangerous crossings.
Louisiana						No reply.
Maine				U. S. Std.		White instead of yellow background. Reflectors at dangerous crossings.
Massachusetts	Yes	Local Authorities	Local Authorities	U. S. Std.	300′	
Maryland						No reply.
Michigan	Yes			U. S. Std.	500′	Cast iron, white background.
Minnesota	No			U. S. Std.		
Mississippi						On Federal Aid Projects. Railroads required by law to furnish "Mississippi Law Stop."
Missouri	No			U. S. Std.	350′ to 450′	"Stop" signs placed at blind crossings.
Montana						None being placed at this time.

TABLE 2—STATEMENT OF ADVANCE WARNING SIGNS AT HIGHWAY CROSSINGS —(Continued)

States	Approach Signs Required by Law	Cost of Installation Borne by	Cost of Maintenance Borne by	Kind of Sign	Location	Remarks
Nebraska	No			U. S. Std.	350′ to 300′	
Nevada	No			U. S. Std.		Red reflectors in addition.
New Hampshire	Yes Act. 1915	Local Authorities	Local Authorities	U. S. Std.	300′	White instead of yellow background.
New Jersey	No			U. S. Std.	250′	White instead of yellow background.
New Mexico	No			U S. Std.		
New York	Yes	Railway	Local Authorities	U. S. Std.		White instead of yellow background.
N. Carolina	Yes, 1923	Railway	Railway	50″x40″ White field black letters bearing "N.C. Law-Stop"	100′	Small sign beneath showing number of tracks.
N. Dakota	No			U. S. Std.	350′	
Ohio	No			U. S. Std.	350′	Initials of R. R. shown in lower half.
Oklahoma	Yes	Railway	Railway	2′ 2″ x 3″ White sheet iron, black letters, "Stop-State Law"		
Oregon	Yes			U. S. Std.	300′	White instead of yellow, background. Red reflector in addition.
Pennsylvania	No	Railway	State	U. S. Std.	300′	White instead of yellow background.
Rhode Island	No			U. S. Std.		
S. Carolina				U. S. Std.		
S. Dakota	Yes			U. S. Std.		Being replaced with U. S. Std. "Stop" signs.
Tennessee				U. S. Std.	300′ to 600′	Std. stop sign in addition.
Texas						Now under consideration.
Utah	No			Various		Beginning this year to use Std. signs.
Vermont	No			U. S. Std.	200′ to 300′	
Virginia	No	Railway	State	U. S. Std.	200′	On same post "RR 200ft.-speed 5 miles per hour."
Washington	No			U. S. Std.	500′	
Wisconsin	Yes			U. S. Std.	350′ to 500′	
Wyoming	No			U. S. Std.		

SUMMARY

Number of states requiring signs	13
Number of states requiring railways to bear cost	8
Number of states using standard highway signs	37

A

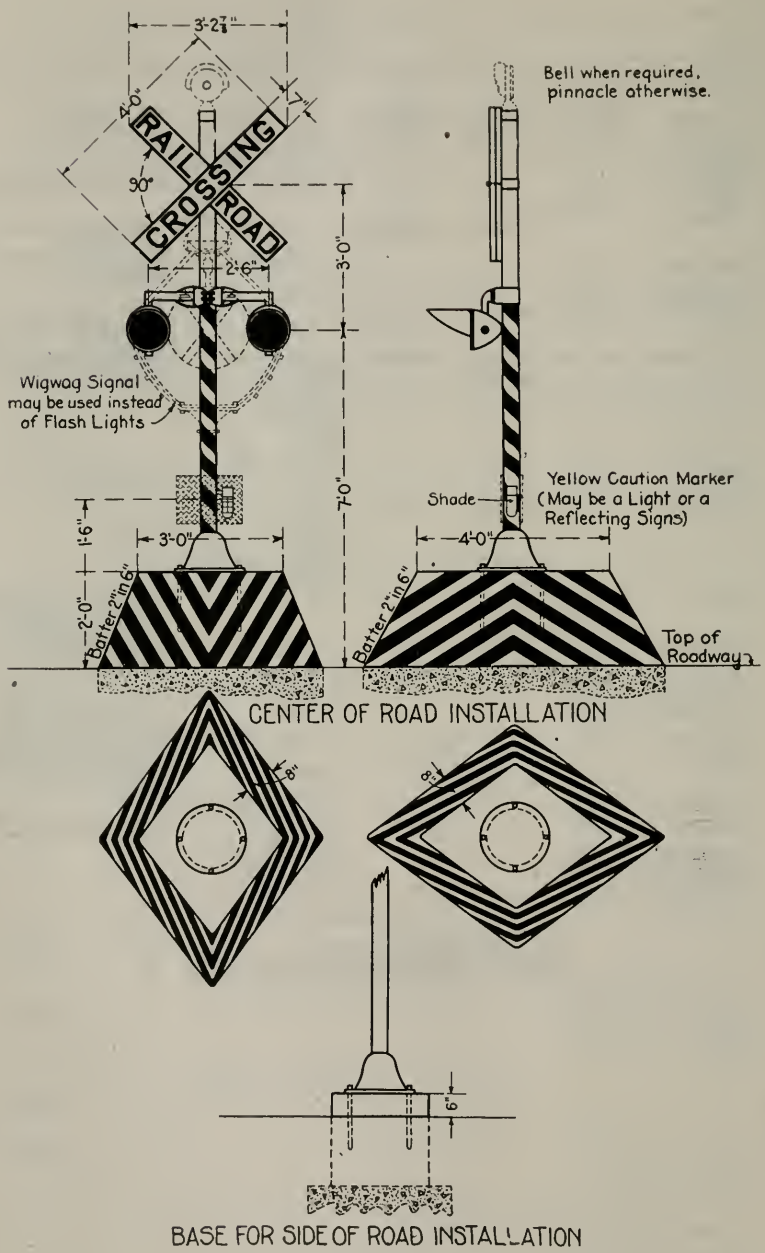
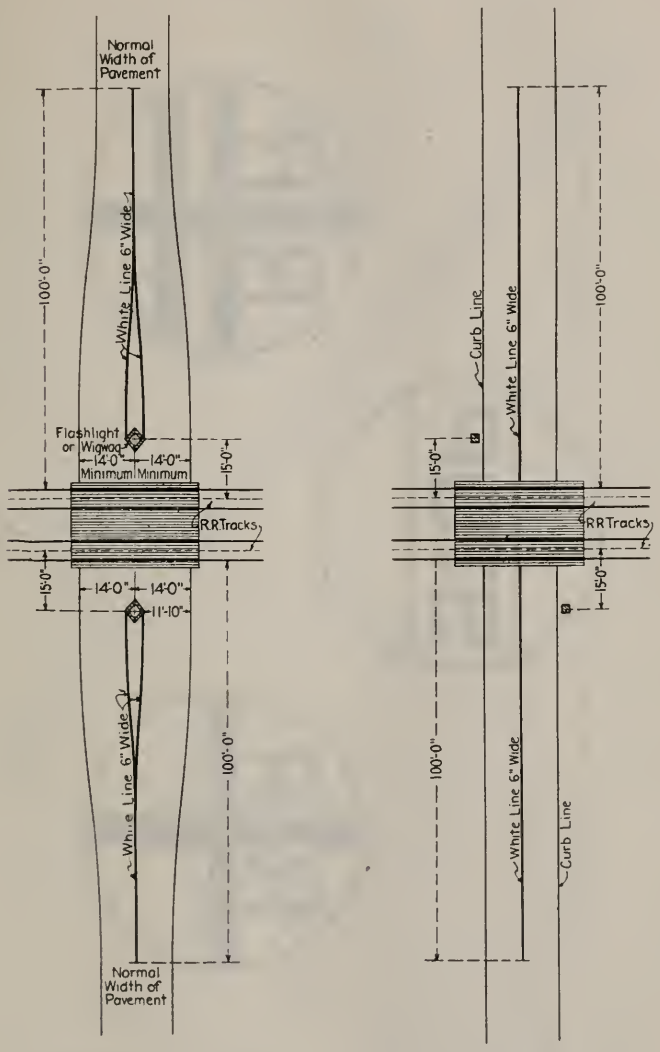

3'-2 7/8"
4'-0"
RAILROAD
CROSSING
90°
2'-6"
3'-0"
7'-0"
Bell when required, pinnacle otherwise.
Wigwag Signal may be used instead of Flash Lights
Yellow Caution Marker (May be a Light or a Reflecting Signs)
Shade
1'-6"
2'-0"
3'-0"
4'-0"
Batter 2" in 6"
Batter 2" in 6"
Top of Roadway
CENTER OF ROAD INSTALLATION
8"
8"
6"
BASE FOR SIDE OF ROAD INSTALLATION

Fig. 1



CENTER OF ROAD INSTALLATION SIDE OF ROAD INSTALLATION

Fig. 2

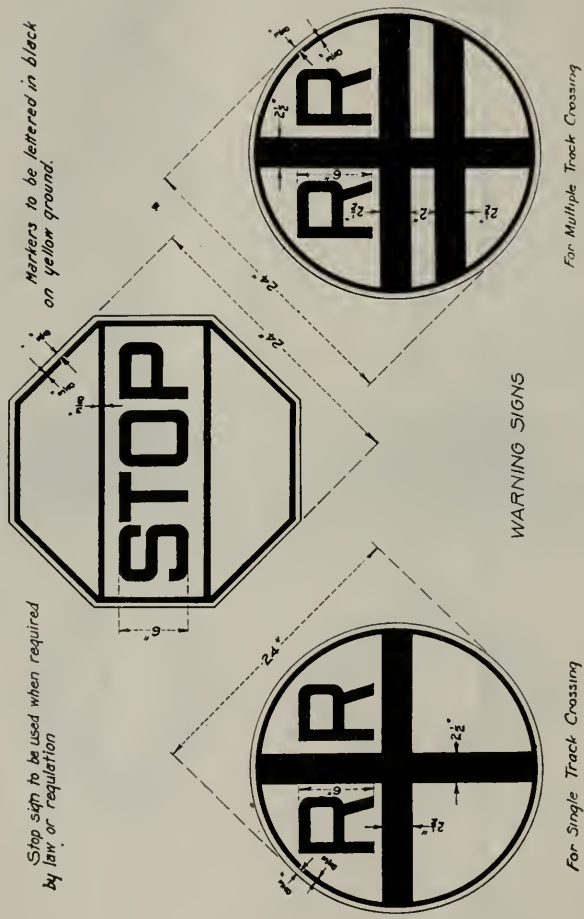

Stop sign to be used when required by law or regulation
STOP
Markers to be lettered in black on yellow ground.
WARNING SIGNS
For Single Track Crossing
For Multiple Track Crossing
RR
RR

Fig. 3

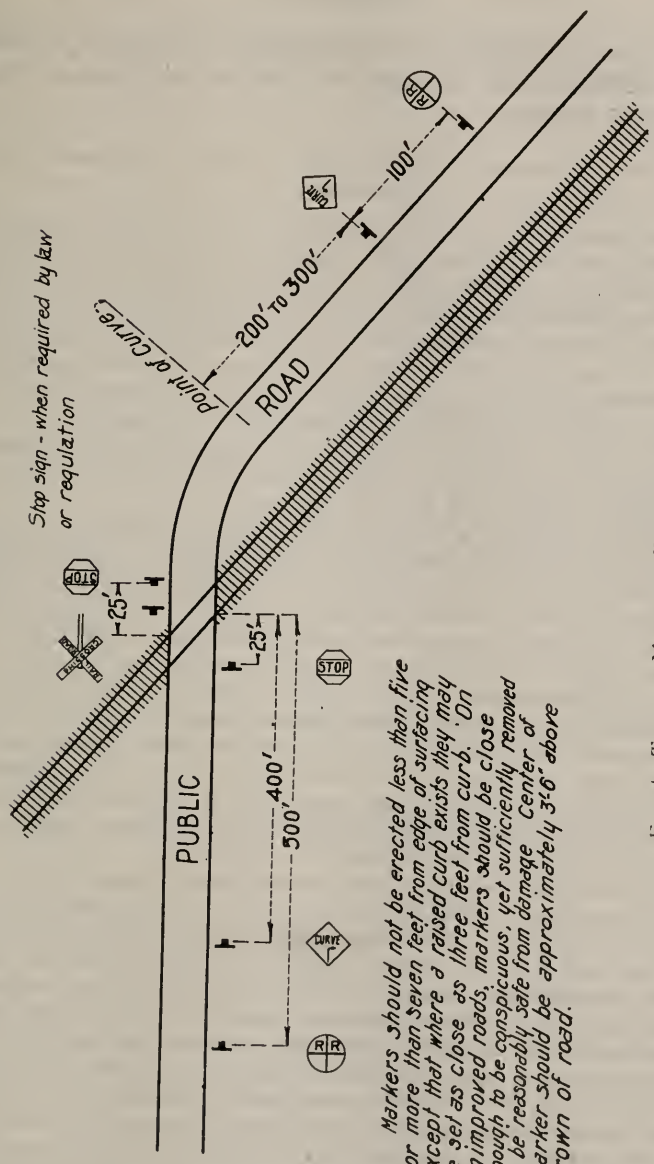


Fig. 4—Typical Marking Railway Crossing

Appendix D

(4) STUDY OF EXCESSIVE NUMBER OF HIGHWAY GRADE CROSSINGS OF RAILWAYS, WITH METHODS FOR THEIR REMOVAL

L. J. Riegler, Chairman, Sub-Committee; H. D. Blake, A. F. Dorley, L. P. Rossiter.

The highway grade crossing problem is one of the most important confronting the railways and public authorities at the present time. The ever-present hazard, and the growing density of highway traffic demand that serious consideration be given as to how the situation can best be met. Statistics show that, notwithstanding the large expenditures for grade separation each year, the number of grade crossings is actually increasing. Every grade crossing constitutes a condition dangerous to traffic and particularly to highway traffic. Accidents are not confined to crossings with bad approaches or poor visibility. Experience has shown that they frequently occur where approaches and visibility are good; lack of caution and care in crossing seemingly offset the other advantages.

Crossing protection is effective in preventing accidents and at many locations is all that is necessary or can be provided. In some locations grade separation is the only solution. There are many other crossings which can be closed or consolidated and a serious effort should be made in this direction. Public interest and safety should impel public authorities to make reduction in the number of grade crossings one of their most important activities. Not only are municipal, county, and state authorities involved in this problem, but it should enlist the active interest of the Federal government by reason of the interstate character of much of the highway traffic. We have come into an era of long tours by automobile travel and long distance bus and truck lines, transcending state limits, and the Federal authority should be interested in the safety, welfare and control of this traffic as well as that of the railways.

The excessive number of grade crossings will continue until some method is provided by which the several arms of the government participate in solving the problem. The difficulties have been discussed from time to time, but until there is genuine activity along feasible lines, not much will be accomplished. Heretofore, grade separation has been depended on, and although great sums have been expended, hardly any impression has been made upon the grade crossing problem; experience has shown that this method by itself is not practicable nor conducive to early results. Lack of progress is not due to physical or engineering difficulties, but is a question of finance. The extraordinary expense attending grade separation has retarded elimination; in fact, the cost is so great as to discourage both the railways and the public authorities in such undertakings.

To solve the problem adequately, some method should be adopted that will eliminate a large number of existing crossings at negligible expense as

compared with grade separation. Such plan would comprise in the first place the prohibition of new grade crossings or their restriction to unavoidable situations. Along with this it should provide for the vacation or closing of existing grade crossings not manifestly necessary for the convenience and welfare of the community, or the diversion or relocation of highways to avoid grade crossings. The cost of diversion usually is less than for grade separation, and it will serve the purpose of elimination as well as grade separation. Grade separation should be limited to situations where none of the other methods can be used and where the traffic is such as to require it.

This plan will result in the greatest good to the greatest number in the shortest time and at less expense. To carry it out, legislation in many of the states would no doubt be necessary. The statutes at the present time have to do with grade separation, and are generally not applicable to highway diversion, abandonment of existing crossings and restriction of new crossings.

RESTRICTION OF NEW GRADE CROSSINGS

Heretofore, grade crossings have been created upon the least provocation and with little formality. Some effort in recent years has been made to restrict the establishment of new crossings but the number is still being increased each year. Statistics of the Interstate Commerce Commission covering the last three years show the number of grade crossings at the ends of each year to be as follows:

1924	232,710
1925	233,633
1926	235,158

To ascertain the present attitude of public authorities, a questionnaire was sent to each of the states and to Canada, requesting information as follows:

1. A concise statement as to what proceedings are necessary to create a new public grade crossing of a highway and the main tracks of a railway.
2. A concise statement as to what proceedings are necessary to close a grade crossing already established.
3. Has there been any tendency in recent years toward restricting the creation of grade crossings.

The questionnaire was sent to the Attorneys-General of the respective states and of Canada. In many instances replies were received from Public Service and Utilities Commissioners, Railroad Commissions and Highway Commissions. The replies indicate that in twenty-six states a tribunal has been erected whose consent must be obtained before a new grade crossing can be established. Usually the authority is vested in a Public Service or Public Utility Commission, but in some cases in Railway or Highway Commissions or the Common Pleas Court of the county. Approval generally is given only after a public hearing and in some cases the railway

may appeal to another commission or to the courts. In two of the states there seems to be no formality required and there are no statutes to cover the subject. Two states prohibit the creation of new grade crossings and a large number prohibit new grade crossings on state roads. In eight states the power to create grade crossings seems to lie with the Board of County Commissioners, though in some cases their action is subject to appeal to the courts.

Nearly all the replies indicate a decided and strong tendency to restrict and in some cases to prohibit additional grade crossings. The replies also indicate that many public authorities are becoming sensible to the gravity of the grade crossing situation as developed within the last few years, due to the startling increase in volume and speed of highway transportation. That the restrictive policy so quickly follows the emergency, augurs well for the future and indicates the early prohibition or rigid restriction in many states of all new grade crossings, unless altogether unavoidable. The railway companies should foster such a policy by an educational campaign, calling attention to the needless hazard and waste at superfluous grade crossings, and the inevitable future cost of grade separation. The uneconomical aspect and unnecessary tax burden of maintaining useless secondary roads with grade crossings should be pointed out.

ELIMINATION OF EXISTING GRADE CROSSINGS

Existing grade crossings can be eliminated by: vacation and closing; diversion and relocation; and by grade separation.

Vacation and Closing

In view of the ease with which grade crossings have heretofore been established, there are, no doubt, many that can be vacated and closed without any substitute and without unreasonable inconvenience to the public or damage to local landowners. Horse-drawn vehicles have practically disappeared and traffic is nearly all borne by motor transport at high velocity. This increases the danger at grade crossings but at the same time makes unnecessary some of the secondary roads. Motor traffic will follow the better improved trunk roads, and secondary roads become obsolete except to reach adjacent localities. Where roads are not abandoned grade crossings upon them may in some cases be closed without unreasonable inconvenience. This would seem to be particularly true in towns and cities having parallel streets a few hundred feet apart where alternate grade crossings could be closed without harm to the general welfare of the community. In such cases better protection can be provided for the remaining crossings. It is a matter that should receive systematic study and planning.

The cost of grade separation has constantly increased so as to be practically prohibitive in many cases, both to the railway company and to the community. Resort to vacation and closing as an alternative follows in logical sequence. Public opinion is slowly but surely changing to meet the new conditions and the railways should be prepared to intelligently co-

operate. It would seem, therefore, that large railway systems can well afford to assign an engineer to the special duty of studying the grade crossing situation, with a view of finding situations where the above methods can be put into practice through negotiations with public authori i

As to whether or not the statutes in the several states are such as to foster such projects or to empower public authorities to carry them out if contrary to the wishes of the property holders is questionable, yet an effort along that line should be made, initiated, if necessary, by the railway companies. Public authorities initiate projects on important highways, but neglect situations on minor highways where the crossings might be closed with little or no expense. It is to the railways' interests to initiate such projects.

Diversion and Relocation

The same study will disclose situations where existing grade crossings may be eliminated by diversion or relocation of the highway and in some cases by the relocation of the railway tracks. With present-day speed of motor cars, extra distance is of little consequence and often a longer route is voluntarily taken to avoid the hazard and possible delay at a grade crossing. A diverted road usually inconveniences only those going to or from the properties immediately adjacent. General traffic across the railway can be handled by through routes where grade separation or protection has been provided. A grade separation project should only be undertaken after a thorough study has been made as to what other crossings may be closed or the roads diverted to a separated crossing, and care should be taken to insure that the project is properly located to adequately handle all general traffic.

Where a highway crosses a railway twice within a few miles, relocation of the highway generally furnishes the best and most economical solution. This condition occurs more often in hilly country, where the railway and highway occupy one or the other side of a valley. In such situations it sometimes is most economical to move the railway tracks. When this is done, the railway must, of course, give up its solidified roadbed for a new one with consequent greater maintenance charges for some years, and due allowance should be made in the distribution of cost of the project.

Where a second highway enters or crosses one to be diverted or relocated the situation becomes complicated, unless the highway can be closed. If investigation demonstrates that it is impractical to close the road, grade separation of one crossing is more economical than for two crossings and there is greater probability that favorable terrain for an over- or underpass may be found along the diverted road. If an entering or cross road is not a part of the general highway scheme and is used only by near landowners for whom it is impractical to provide other means of ingress and egress, then the crossing should be vacated as a public road and restricted to the status of a private crossing.

An effort should be made to locate new highways and relocate or divert existing highways, through structures already existing on the railway In-

vestigation when highways are being improved may often show economy in constructing along a new route, while at the same time eliminating a dangerous crossing.

Grade Separation

Where an important public highway crosses a railway at grade, and public safety and convenience requires elimination of the crossing, and the public need is such that the crossing cannot be closed or the highway or traffic diverted, grade separation is the only solution.

No grade separation project should be undertaken until a thorough investigation has been made to fit the project into the general scheme of highway transportation. A study should also be made to determine the possibility of diverting other roads to the crossing to be separated, so as to eliminate as many crossings as possible with the one structure. Grade separation projects should not be undertaken without complete investigation to determine whether or not such construction will interfere with future improvements of the railway.

Summarizing

In approaching the problem, it will be necessary to take into consideration the viewpoint of interested citizens and property-owners. Their viewpoint is essentially different from that of the railways, and to solve the problem in a large way, the arguments of both sides must be given consideration.

When a grade crossing is to be closed, the people who live adjacent to it think very largely in terms of their own convenience. Frequently, objections are entered because the change will make it necessary to travel longer distances in going to market or in visiting their neighbors. The question of developing property adjacent to cities and in undeveloped portions of the state, as a whole, makes it difficult to interest property-owners in closing projects. Where a road is to be diverted, the property-owners on the old road have certain rights which seem to become very valuable at such times and which are used as arguments to prevent the project. It is the viewpoint of many people that the railway is an intruder and that the railway company has large sums of money to pay for everything connected with its physical property, and many people feel that the arguments of economy and safety advanced by the railways are not true.

Between these people and the railways stand the public officials, acting in conformity with the police power or public welfare clauses of the Constitution, which give them certain specific authority to act in the public interest. It is their problem to work out a solution as nearly satisfactory as possible. These officials are frequently limited in the performance of their duty by lack of funds and are sometimes hampered by public opinion as described above. On the other hand, if it can be shown that the closing of a crossing or diversion of a road is in the public interest, they can usually be depended upon to support such project.

It can be said that the railways appreciate the objectional features of grade crossings and the desirability of reducing their number and are in a general sense favorable to such projects within the limits of their ability to pay, and providing a fair apportionment of the cost can be agreed upon. Heretofore, because of the general mandatory nature of grade separation laws and the inequitable apportionment of cost, the railways have taken a more or less defensive attitude towards the subject. They have, so to speak, had their backs to the wall, awaiting the next move of the public authorities. Inflexibility of statutes withholding from public authorities sufficient discretion to enter into workable agreements with the railways has also retarded elimination. Greater opportunity to exercise discretion by public authorities and a fairer apportionment of cost under the statutes should be met by the railway companies in closer co-operation.

The immensity of the subject, the extraordinary expense involved in grade crossing elimination, the inequitable apportionment of cost under present status, and the impracticability of grade separation as a means to get early results, should be kept before the public and public authorities. The economy and feasibility of other methods than grade separation should be emphasized.

Recommendations

It is recommended that the American Railway Association be requested to adopt means and use its influence to get before the public and public authorities the desirability of enacting such laws as will assist in restricting the creation of new grade crossings, permit closing and vacation of existing grade crossings, relocation and diversion of highways to avoid or eliminate grade crossings and finally for grade separation. The statutes should give public authorities more discretion to enter into agreements with the railways as to method of elimination, procedure and distribution of cost. An effort should be made to enlist the aid of the Federal government and to secure a more equitable apportionment of cost from state, county and municipal authorities.

It is recommended that the railways, particularly the larger systems, definitely assign Engineers to study the grade crossing situation on their lines, with special reference to the abandonment or consolidation of existing crossings, the assignment to include the necessary study of local political and highway conditions, highway and grade crossing laws, and method of procedure.

It is recommended that the railways then take the initiative in negotiating with town boards, county, and state officials, with a view to closing or combining those crossings where the survey indicates that the conditions are favorable.

Appendix E

(5) STUDY AND REPORT ON THE ECONOMIC ASPECTS OF GRADE CROSSING PROTECTION IN LIEU OF GRADE SEPARATION

A. H. Utter, Chairman, Sub-Committee; L. B. Curtiss, T. E. Rust, R. L. Huntley, G. P. Palmer, E. H. Roth, C. E. Herth.

Data on which to base a report on this subject is being assembled and studied but considerable additional information must necessarily be secured before making any reliable statement on the merits of protection in lieu of separation.

Therefore your Committee presents a report of progress and recommends continued study of the subject.

Appendix F

(8) STUDY AND REPORT ON (a) LAWS AND REGULATIONS AFFECTING THE APPORTIONMENT OF FEDERAL AID; (b) THE PROPER FORM AND CHARACTER OF DIVISION OF COSTS OF SEPARATION OF GRADES AS BETWEEN THE RAILWAY, STATE, COUNTY, MUNICIPAL OR OTHER CORPORATION

F. Ringer, Chairman, Sub-Committee; R. L. Huntley, J. F. Deimling, F. G. Jonah, F. J. Stimson, A. E. Korsell, J. Astrue, J. G. Brennan, W. J. Towne, H. D. Blake.

(a) LAWS AND REGULATIONS AFFECTING THE APPORTIONMENT OF FEDERAL AID

Provisions of Federal Highway Act as Amended and of Regulations Pertaining Thereto:

The Secretary of Agriculture is authorized to co-operate with the states, through their respective highway departments, in the construction of rural post roads. The term "rural post roads" shall be construed to mean any public road a major portion of which is now used, or can be used, or forms a connecting link not to exceed ten miles in length of any road or roads now or hereafter used for the transportation of United States mails, excluding every street and road in a place having a population, as shown by the latest Federal census, of 2500 or more, except that portion of any such street or road along which within a distance of one mile the houses average more than 200 ft. apart. In approving projects to receive Federal aid the Secretary of Agriculture shall give preference to such projects as will expedite the completion of an adequate and connected system of highways interstate in character.

Before any projects are approved in any state, such state shall select or designate a system of highways not to exceed 7 per centum of the total highway mileage of such state. Upon this system all Federal aid shall be expended. Highways which may receive Federal aid shall be divided into two classes, one of which shall be known as primary or interstate highways, and shall not exceed 3/7 of the total mileage which may receive Federal aid, and the other which shall connect or correlate therewith and be known as secondary or intercounty highways, and shall consist of the remainder of the mileage which may receive Federal aid. The Secretary of Agriculture shall have authority to approve in whole or in part the systems as designated or to require modifications or revisions thereof.

Before any project shall be approved by the Secretary of Agriculture for any state, such state shall make provisions for state funds required each year for construction, reconstruction, and maintenance of Federal aid highways within the state. Any state desiring to avail itself of the benefits of this act shall submit to the Secretary of Agriculture project statements setting forth proposed construction of any primary or secondary highway therein. If the Secretary of Agriculture approves the project, the state highway department shall furnish to him such surveys, plans, specifications and estimates therefor as he may require. When the Secretary of Agriculture approves such surveys, plans, specifications and estimates he shall notify the state highway department and immediately certify the fact to the Secretary of the Treasury. The Secretary of the Treasury shall thereupon set aside the share of the United States payable under this act on account of such projects, which shall not exceed 50 per centum of the total estimated cost thereof, and shall not exceed $15,000 per mile, exclusive of the cost of bridges of more than 20 feet clear span. The term "bridges" includes railroad grade separations, whether by means of overhead or underpass crossings.

The construction and reconstruction of the highways or parts of highways under provisions of the Federal aid act and all contracts, plans, specifications, and estimates relating thereto shall be undertaken by the state highway departments, subject to the approval of the Secretary of Agriculture. When the Secretary of Agriculture shall find that any project approved by him has been constructed or reconstructed in compliance with such plans and specifications, he shall cause to be paid to the proper authorities of said state the amount set aside for such project. The Secretary of Agriculture may make payments on such construction or reconstruction as the work progresses, but these payments, including previous payments, if any, shall not be more than the United States pro rata part of the value of the labor and materials which have been actually put into such construction or reconstruction in conformity to said plans and specifications. Vouchers showing amounts expended on any project and the amount claimed to be due from the Federal government on account thereof shall be submitted by the state highway department to the Bureau of Public Roads. Payments shall be made by the Secretary of the Treasury on warrants drawn by the Secretary of Agriculture.

The Secretary of Agriculture, after deducting proportion specified for administration and research, shall apportion the appropriation for each fiscal year among the several states in the following manner: One-third in the ratio which the area of each state bears to the total area of all the states; one-third in the ratio which the population of each state bears to the total population of all states as shown by the latest available Federal census; one-third in the ratio which the mileage of rural delivery routes and star routes in each state bears to the total mileage of rural delivery and star routes in all states.

Each state highway department shall file with the Secretary of Agriculture a state map showing the proposed Federal aid highway system and in-

dicating the primary and the secondary portions thereof in such form and with such information as he may require. The Secretary of Agriculture, through his authorized representatives, will make an examination of the proposed system and will from time to time notify the state highway department of the acceptability of the parts of the system examined. The state shall make formal request for the approval of the Secretary of Agriculture, which shall be accompanied by a state map showing the full proposed Federal aid highway system with the primary and secondary highways upon which formal approval is requested.

Within two years after this act takes effect (act approved November 9, 1921) the Secretary of Agriculture shall prepare, publish and distribute a map showing the highways and forest roads that have been selected and approved as a part of the primary or interstate, and the secondary or intercounty systems, and at least annually thereafter shall publish supplementary maps showing his program and the progress made in selection, construction and reconstruction.

Grade crossings occurring on the Federal aid highway system shall be classified.

The Sub-Committee understands that the present practice, under the rulings of the Bureau of Public Roads, is that Federal aid may be allotted to construction of railway grade crossing separations to the extent of 50 per centum of the cost thereof, except that the Federal authority has declined to reimburse the state for more than the amount actually paid by the state.

Under the provision of the Federal aid act a definite allotment of funds is made to each state, which is the maximum of Federal aid which it may receive from the amount appropriated. It follows, therefore, that if Federal aid is not used for paying any part of a railway grade separation, the state has an accordingly greater amount left for use on other road improvements. There is a tendency on the part of some states to apply Federal aid in this manner, and as a result fewer grade crossings are eliminated than would otherwise be done.

It is understood there is no provision of the Federal aid act which railway companies can use to compel the states, through legal proceedings, to apportion part of the Federal aid allotment to a particular grade separation project, and it is possible for necessary grade separations to be segregated and kept out of Federal aid projects.

It is understood that classification of railway grade crossings of Federal aid highways has not yet been completed. It is the view of the Sub-Committee that a statement showing by states classification of railway grade crossings of highways of the Federal aid system should be prepared and published annually by the Bureau of Public Roads.

Provisions of States Governing Division of Costs of Highway Grade Crossing Eliminations

State	*Authority vested in*	*Remarks*
Alabama	Courts	Not specifically defined by statutes.
Arkansas	Courts	Not specifically defined by statutes.
Arizona	Corp. Com.	
California	State Com.	
Colorado	Pub. Util. Com.	
Connecticut	Statutes	(a) Highway constructed after railway: municipality maximum 50%, railway the remainder. (b) Highway constructed before railway: municipality maximum 25%, railway the remainder. (c) Elimination ordered by Pub. Util. Com.: state 25% and railway the remainder or 75%.
Delaware	Courts	Not specifically defined by statutes.
Florida	R. R. Com.	
Georgia	Courts	Not specifically defined by statutes.
Idaho	Courts	Not specifically defined by statutes.
Illinois	Commerce Com.	
Indiana	Statutes	Maximum R. R. proportion 50% for state highways, for other roads 75%.
Iowa	R. R. Com.	
Kansas	Courts	Not specifically defined by statutes.
Kentucky	Statutes	Code fixes division of cost.
Louisiana	Pub. Serv. Com.	
Maine	Statutes	65% R. R., 25% state, 10% municipality.
Maryland	Statutes	50% R. R., 50% state for state roads.
Massachusetts	Special Com.	25% state, 10% munic. and not less than 65% R. R.
Michigan	Pub. Util. Com.	
Minnesota	R. R. & Warehouse Com.	
Mississippi	Statutes	Code places entire expense on railway.
Missouri	Pub. Serv. Com.	Participation by State highway commission limited by statutes to 50%.
Montana	R. R. & Warehouse Com. Courts	For new highways. No specific statutes for existing highways.
Nebraska	Ry. Com.	
Nevada	Pub. Serv. Com.	
New Hampshire	Courts	No specific statutes but can require railway by law to pay entire cost.
New Jersey	Statutes	Railway bears entire cost with some minor exceptions.
New Mexico	Courts	Not specifically defined by statutes.
New York	Statutes	50% railway, 25% state, 25% munic.
North Carolina	Corp. Com.	
North Dakota	R. R. Com.	
Ohio	Statutes	Main market roads, 50% railway, 50% state. Other roads, 65% railway, 35% munic.

State	*Authority vested in*	*Remarks*
Oklahoma	Corp. Com.	Participation by city, town or municipality limited by statutes to 50%.
Oregon	Statutes	50% railway, 50% state.
Pennsylvania	Pub. Serv. Com.	With right to appeal to Superior Court.
Rhode Island	Courts	Not specifically defined by statutes.
South Carolina	R. R. Com.	
South Dakota	R. R. Com.	
Tennessee	Courts	Not specifically defined by statutes.
Texas	Courts	Not specifically defined by statutes.
Utah	Pub. Util. Com.	
Vermont	Statutes	65% R. R., 25% state, 10% munic.
Virginia	State. Corp. Com.	Some limitations by statutes.
Washington	Dept. of Pub. Works	
West Virginia	Statutes	50% R. R., 50% state, county or munic.
Wisconsin	R. R. Com.	
Wyoming	R. R. Com.	

SUMMARY

Division of costs determined by state commissions	24 states
Division of costs determined by statutes	13 states
Division of costs determined by agreements or by courts..	11 states
Total	48 states

(b) PROPER FORM AND CHARACTER OF DIVISION OF COSTS OF SEPARATION OF RAILWAY GRADE CROSSINGS

Replies to questionnaire with reference to division of costs for highway grade crossing eliminations, constructed from date of Federal valuation to December 31, 1926, have been tabulated and a summary is appended hereto as Exhibit "A."

Recommendations

1. Authority to order grade crossing eliminations, separations, or proper protection at grade crossings should be vested in the state commission or other state body having jurisdiction over railways, which should also determine and enforce proper division of cost between the railways and the public.

2. The Federal Highway Act should be amended to provide that every elimination of a grade crossing of a railway with a Federal aid highway should be included in a Federal aid project and Federal aid should be applied to such crossing elimination to the extent of 50 per cent of the cost thereof.

3. The cost of a grade crossing elimination in excess of the Federal aid allotment thereto should be apportioned between the state and/or subdivision thereof and the railway company on the basis of the conditions at such crossing, and of the benefits arising from such elimination.

Exhibit A

SUMMARY OF REPLIES TO QUESTIONNAIRE WITH REFERENCE TO DIVISION OF COSTS OF ELIMINATIONS OF GRADE CROSSINGS OF FEDERAL AID HIGHWAYS CONSTRUCTED FROM DATE OF FEDERAL VALUATION TO DECEMBER 31, 1926

Classification:

Class 1—Grade crossing elimination by relocation of highway.

Class 2—Crossing of primary highway and trunk line of two or more tracks.

Class 3—Crossing of single track railway and primary highway or of trunk line railway and secondary highway.

"A" Crossings for Which Cost Borne by Federal Aid Is Reported

(Miles of road reporting, 70,808)

	Number of Crossings	*Railway*	*Cost Borne by State*	*Federal Air*	*Total*
Class 1	30	$ 222,700	$* 582,674	$* 702,441	$*1,507,815
Av. per crossing		7,423	19,422	23,415	50,260
Av. % per crossing		15	38	47	100
Class 2	18	$ 372,983	$ 431,243	$ 257,617	$ 1,061,843
Av. per crossing		20,721	23,958	14,312	58,991
Av. % per crossing		35	41	24	100
Class 3	80	$1,166,875	$ 674,456	$ 847,008	$ 2,688,339
Av. per crossing		14,586	8,431	10,587	33,604
Av. % per crossing		44	31	25	100
Totals all classes	128	$1,762,558	$ 1,688,373	$1,807,066	$ 5,257,997
Av. per crossing		13,770	13,190	14,118	41,078
Av. % per crossing		34	32	34	100

"B" Crossings for Which Cost Borne by Federal Aid Is Not (In Reports) Segregated from Cost Borne by State

(Miles of road reporting, 71,664)

	Number of Crossings	*Railway*	*Cost Borne by State*	*Federal Air*	*Total*
Class 1	66	$ 243,197	$* 351,724	$ X	$* 594,921
Av. per crossing		3,685	5,329		9,014
Av. % per crossing		41	59		100
Class 2	22	$ 419,025	$ 401,484	$ X	$ 820,509
Av. per crossing		19,047	18,249		37,296
Av. % per crossing		51	49		100
Class 3	148	$1,488,635	$ 1,413,324	$ X	$ 2,901,959
Av. per crossing		10,058	9,549		19,607
Av. % per crossing		51	49		100
Totals all classes	236	$2,150,857	$ 2,166,532	$ X	$ 4,317,389
Av. per crossing		9,114	9,180		18,294
Av. % per crossing		50	50		100

All Crossings Reported

(Miles of road reporting, 101,946)

	Number of Crossings	Railway	Cost Borne by State	Federal Air	Total
Class 1	96	$ 465,897	$*1,636,839	$ X	$*2,102,736
Av. per crossing		4,853	17,050		21,903
Av. % per crossing		22	78		100
Class 2	40	$ 792,008	$ 1,090,344	$ X	$ 1,882,352
Av. per crossing		19,800	27,259		47,059
Av. % per crossing		42	58		100
Class 3	228	$2,655,510	$ 2,934,788	$ X	$ 5,590,298
Av. per crossing		11,647	12,872		24,519
Av. % per crossing		47	53		100
Totals all classes	364	$3,913,415	$ 5,661,971	$ X	$ 9,575,386
Av. per crossing		10,751	15,555		26,306
Av. % per crossing		41	59		100
Totals classes 2 and 3 only	268	$3,447,518	$ 4,025,132	$ X	$ 7,472,650
Av. per crossing		12,864	15,019		27,883
Av. % per crossing		46	54		100

Notes.—Cost shown as borne by state include amounts contributed by local authorities.

"X"—Costs borne by Federal aid are included in amounts shown as borne by states.

"*"—Includes cost of constructing long stretches of highways which were relocated for general improvement, the elimination of grade crossings being incidental.

	Miles of Road Operated I. C. C. 1925	Per Cent
Roads reporting costs of grade separation shown above	101,946	39
Roads reporting no grade separations of Federal aid highways	11,470	4
Roads not reporting or information incomplete	146,549	57
Total I. C. C. Class I, II, and III railways in U. S. 1925	259,965	100

REPORT OF COMMITTEE XVII—WOOD PRESERVATION

F. C. Shepherd, *Chairman;*
W. G. Atwood,
R. S. Belcher,
Z. M. Briggs,
C. S. Burt,
G. M. Davidson,
G. F. Eberly,
J. E. Fanning,
E. B. Fulks,
Andrew Gibson,
W. R. Goodwin,
R. S. Hubley,
W. H. Kirkbride,
G. P. MacLaren,
C. F. Ford, *Vice-Chairman;*
F. D. Mattos,
W. D. Pender,
L. J. Reiser,
W. R. Rhodes,
Dr. Hermann von Schrenk,
W. L. Smith,
O. C. Steinmayer,
G. C. Stephenson,
T. H. Strate,
C. Marshall Taylor,
J. H. Waterman,
Galen Wood,
Committee.

To the American Railway Engineering Association:

This Committee respectfully presents herewith a report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) Submit definitions of terms used in Wood Preservation (Appendix B).

(3) Report upon Service Test Records for Treated Ties (Appendix C).

(4) Investigate and report on Piling used for Marine Construction (Appendix D).

(5) Study and report upon the effect of preservative treatment with:
- (a) Creosote and Petroleum (Appendix E).
- (b) Zinc Chloride and Petroleum (Appendix F).
- (c) Air-Seasoned Douglas Fir (Appendix G).

(6) Outline of work for ensuing year.

Action Recommended

Your Committee recommends that Appendix A, Revision of Manual; Appendix B, Definitions of Terms; Appendix C, Service Test Records; Appendix D, Marine Piling Investigation; Appendix E, Treatment with Creosote and Petroleum; Appendix F, Treatment with Zinc Chloride and Petroleum, and Appendix G, Treatment of Air-Seasoned Douglas Fir, be accepted as information.

Bulletin 304, February, 1928.

Outline of Work for Ensuing Year

1. Revision of Manual.
2. Submit definitions of terms used in Wood Preservation.
3. Report upon Service Test Records for Treated Ties.
4. Investigate and report on Piling used for Marine Construction.
5. Study and report upon the effect of preservative treatment with:
   (a) Creosote and Petroleum.
   (b) Zinc Chloride and Petroleum.
6. Specifications for Treatment of Air-Seasoned Douglas Fir.
7. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON WOOD PRESERVATION,

F. C. SHEPHERD, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

Dr. Hermann von Schrenk, Chairman, Sub-Committee; R. S. Belcher, C. S. Burt, E. B. Fulks, W. R. Goodwin, F. D. Mattos, O. C. Steinmayer, G. C. Stephenson, Galen Wood.

This Sub-Committee feels that in view of the very extensive revision of the Manual, as offered and adopted at the last convention, it has no report to offer for this year other than that of progress.

Appendix B

(2) DEFINITIONS OF TERMS USED IN WOOD PRESERVATION

E. B. Fulks, Chairman, Sub-Committee; Z. M. Briggs, G. M. Davidson, W. D. Pender, R. S. Hubley, Dr. Hermann von Schrenk, G. C. Stephenson, O. C. Steinmayer, Galen Wood.

This Sub-Committee was appointed this year with instructions to "submit definitions of terms used in wood preservation." One meeting was held at which it was decided to confine the work for this year to the preparation of definitions of the more important terms now appearing in the Manual. This work has been carried on by correspondence and a list of definitions is submitted.

Absorption, Gross.—Total amount of preservative injected into wood during the treating operation.

Absorption, Initial.—The amount of preservative absorbed by the wood while the retort is being filled.

Absorption, Net.—The amount of preservative left in the wood after completion of the treating operation.

Adzing.—See Tie, Adzed.

Air-Dried.—Seasoned by exposure to the atmosphere until there is no further appreciable loss in weight due to evaporation of moisture.

Air-Seasoned.—See Air Dried.

Artificial Seasoning.—See Seasoning, Artificial.

Borer, Increment.—See Increment Borer.

Boring.—See Tie, Bored.

Charge (noun).—All the wood assembled for treatment in one cylinder at one time.

Charge (verb).—To place the wood in the cylinder for treatment.

Charging Tank.—See Tank, Charging.

Coal Tar.—The non-aqueous portion of the liquid distillate obtained during the carbonization of bituminous coal.

Coal-Gas Tar—Gas-House Tar.—Coal tar produced during the manufacture of illuminating gas in gas retorts.

Coke-Oven Tar.—Coal tar produced during the manufacture of coke in by-product coke ovens.

Coke Test.—A test used to determine the amount of "fixed carbon" in creosote or tar.

Creosote.—A distillate from coal tar. It is heavier than water; usually contains separated crystals when cold but becomes liquid when heated; its distilling range lies about 200 deg. C. and the major portion distills below 360 deg. C.

Creosote Coal-Tar Solution.—Solution of coal tar in creosote in various proportions. Usually contains 20 to 40 per cent coal tar.

Cylinder, Treating.—A horizontal steel tank in which timber is placed while being treated with preservative under pressure. A retort.

Density (of wood).—A term used to denote the relative proportion of spring wood and summer wood and also the number of annual rings per inch.

Distillation.—The process of separating creosote or tar into "fractions" having different boiling temperatures. The material to be distilled is placed in a distilling flask, the temperature gradually raised and the vapors given off at various temperatures are condensed and collected separately.

Drain Tank.—See Tank, Drain.

Empty Cell Treatment.—A treatment in which the cell walls in the treated portion of the wood remain coated with preservative, the cells being empty or only partially filled.

Emulsion.—A mixture of liquids insoluble in one another. In wood preserving, a mixture of creosote or other oils and water or solution of a salt in water.

Expansion Factor.—Coefficient of expansion. A constant representing the change in volume of creosote for one degree of temperature.

Final Vacuum.—See Vacuum, Final.

Float Test.—A test used to measure viscosity. Used in testing creosote as a means of judging the amount of tar in solution.

Full Cell Treatment.—A treatment in which the cells in the treated portion of the wood remain either partially or completely filled with preservative.

Gas-House Tar.—See Coal-Gas Tar.

Gages, Recording.—See Recording Gages.

Gross Absorption.—See Absorption, Gross.

Heart Wood.—The inner portion of a tree in which the wood cells are dead and perform no vital function.

Impregnation.—Penetration of preservative into wood.

Incising.—Puncturing the lateral surface of resistant wood as an aid in securing penetration by the preservative.

Increment Borer.—An auger with a hollow shaft used in removing a small core from wood for examination. Convenient for determining the depth of penetration in treated timber.

Initial Absorption.—See Absorption, Initial.

Initial Vacuum.—See Vacuum, Initial

Measuring Tank.—See Tank, Measuring.

Mixing Tank.—See Tank, Mixing.

Net Absorption.—See Absorption, Net.

Oil Seasoning.—See Seasoning Oil.

Penetration.—The depth to which preservative enters wood through both lateral and end surfaces.

Perforating.—Same as Incising.

Pump, Pressure.—A hydraulic pump used to force the preservative into wood.

Pump, Vacuum.—Pump used for reducing atmospheric pressure in treating cylinders.

Recording Gages.—Automatic instruments for measuring and recording graphically the time, temperature, pressure and vacuum used in a treating operation.

Refractory Timber.—Timber which offers unusual resistance to the entrance of preservative; timber which is difficult to treat.

Refusal Treatment.—Treatment of timber by pressure until absorption of preservative practically ceases.

Refusal Point.—The point on the gage beyond which no more preservative can be forced into timber.

Retort.—A cylinder used for holding timber while it is being treated with preservative under pressure.

S Iron.—A piece of flat iron, sharpened on one edge and bent to the shape of the letter S, C or Z used for driving into the end of a piece of timber to prevent splitting and checking.

Sample Thief.—Apparatus for taking samples of preservatives from tanks or other containers.

Sap Drum.—Small tank or drum, located below treating cylinder for collecting sap or condensation during steaming.

Sap Wood.—The outer portion of a tree in which the wood cells are alive and perform vital functions.

Seasoned, Air.—See Air Dried.

Seasoning, Artificial.—Removing moisture from wood by some means other than air drying.

Seasoning, Steam.—See Steaming.

Seasoning, Oil.—Seasoning wood artificially by immersion in oil heated above the boiler point of water at atmospheric pressure or under vacuum.

Steaming.—Preparing green timber for treatment by subjecting it to the action of steam in a closed cylinder.

Storage Tank.—See Tank, Storage.

Tank, Charging.—A calibrated tank used for supplying preservative to the cylinder and measuring the quantity of preservative used in the treating process.

Tank, Drain.—Usually a horizontal, cylindrical tank so located that the surplus preservative can be drained into it by gravity upon completion of the treatment.

Tank, Measuring.—A calibrated tank sometimes used, in addition to the charging tank, for measuring the amount of preservative forced into the wood.

Tank, Mixing.—Tank equipped with agitating apparatus for mixing preservatives or making solutions.

Tank, Storage.—Tank for storing preservatives.

Tank, Unloading.—Usually a horizontal tank placed below a standard gage track, to enable tank cars to be unloaded by gravity.

Tar, Coal.—See Coal-Gas Tar.

Tar, Coke-Oven.—See Coke-Oven Tar.

Tar, Water-Gas.—See Water-Gas Tar.

Tie, Adzed.—Tie prepared with smooth surface at the rail bearing points.

Tie, Bored.—Tie with holes bored where spikes are to be driven.

Toxic, Poisonous.—Capable of killing wood destroying organisms.

Treating Cylinder.—See Cylinder, Treating.

Ullage.—The amount which a tank or vessel lacks of being full.

Vacuum, Final.—Vacuum applied as the final operation in the treating process; used to aid in the removal of surplus preservative injected and in drying the timber.

Vacuum, Initial.—Vacuum sometimes applied as the first step in the treating operation for the purpose of removing air from the wood cells.

Water-Gas Tar.—Tar produced in the manufacture of carburetted water-gas by the decomposition of petroleum oil by heat in the presence of blue gas.

Zinc Chloride.—A salt formed by the action of hydrochloric acid on zinc. Used in solution in water for preserving timber.

Zone, Samples.—Samples from a tank taken at a certain depth and in such a manner that they represent aliquot portions of the contents of the vessel.

Conclusions

It is recommended that this report be accepted as information and the subject be continued.

Appendix C

(3) REPORT UPON SERVICE TEST RECORDS FOR TREATED TIES

C. F. Ford, Chairman, Sub-Committee; C. S. Burt, Z. M. Briggs, G. M. Davidson, G. F. Eberly, Andrew Gibson, W. R. Goodwin, W. R. Rhodes, W. L. Smith, T. H. Strate, J. H. Waterman.

1. A table is given of additional completed service tests of cross-ties reported by the Forest Products Laboratory. This table is a supplement to the complete table printed in 1926.

2. The Committee has revised and extended the table of tie renewals per mile which now includes 26 railroads. In addition to tabulating the insertions and renewals as given in this table, the Committee has made a detailed study of tie insertion records of a good many of the railroads whose tie performance is recorded in this table. It was hoped that a definite relationship could be shown between the number of treated ties inserted from year to year, and the tie renewals per mile in subsequent years. After a very extended study and analysis, it was found impossible to do this for the following reasons:

The number of ties removed per mile in any one year will depend upon a considerable number of definite factors, the more important of which are as follows:

(1) The proportion of untreated and treated ties laid each year.
(2) The type of treatment of the ties inserted, including herein the kind and the quantity of preservative used, and the character of the treatment.

RECORD OF COMPLETED SERVICE TESTS OF TIES

Supplementary to the Completed Records Published in the 1926 and 1927 A. R. P. A. and A. R. R. A. Proceedings.

Species	Dimensions	Form	Preparation	Preservative	Process	Absorption Lbs. per cu. ft.	Number of ties	Railroad	Location	Date set	Track condition: Tie plates Kind	Tie plates Size (inches)	Kind of splices	Ballast	Traffic: Tons per year	Date removed	Average life Years	Average life Defects	Cause of removal
Beech[2]	—	Sawed	—	Creosote	Dipping	4.5	69	A.T. & S.F.	Illinois Division	1913	Yes	—	—	Gravel	—	1917	4.0	R.R.	
Birch, yellow	—	—	—	Zinc chloride	Untreated	—	100	O. & R.V.	Wamac, Ill.	1914	—	—	—	—	—	1922	4.8	F.P.L.	
Cedar[2]	—	—	—	Zinc chloride	Untreated	—	56	A.T. & S.F.	Los Angeles Division	1913	—	—	—	Gravel	—	1918	5.0	R.R.	
Cedar	—	—	—	Zinc chloride	Untreated	—	70	" " "	Valley Division	1916	Yes	—	—	Rock	—	1925	8.9	R.R.	
Douglas fir	—	Sawed	—	Zinc chloride	Untreated	—	127	" " "	Albuquerque Division	1916	—	—	—	—	—	1925	5.8	R.R.	
Douglas fir	—	Sawed	—	Zinc chloride	Untreated	—	139	A.T. & S.F.	Albuquerque Division	1916	—	—	—	—	—	1921	3.1	R.R.	
" "	—	"	—	"	"	—	551	" " "	" " "	1911	—	—	—	—	—	1922	1.4	R.R.	
Gum	—	"	Seasoned	Zinc chloride	Burnett	.51	88	" " "	Missouri Division	1911	Yes	—	—	Gravel	—	1922	6.2	R.R.	
Hemlock	—	—	—	Zinc chloride	Untreated	—	100	O. & R.V.	Oakaloosa, Iowa	1914	—	—	—	—	—	1921	7.0	F.P.L.	
"	6"x7"x8'	Sawed	Green	Zinc chloride	"	—	100	" " "	Wamac, Ill.	1914-15	Sellers	—	Out	Gravel	—	1925	8.9	F.P.L.	
Mangle Prieta	—	—	—	Zinc chloride	Untreated	—	332	A.T. & S.F.	New Mexico Division	1912	Yes	—	—	Rock	—	1922	6.8	R.R.	
Oak[2]	—	Hewed	—	"	"	—	53	" " "	Arkansas River Division	1911	—	—	—	Rock & gravel	—	1916	5.0	R.R.	
Oak[2]	—	"	—	"	"	—	61	" " "	Beaumont Division	1912	—	—	—	—	—	1917	5.0	R.R.	
Oak[2]	—	"	—	"	"	—	56	" " "	Colorado Division	1913	—	—	—	Slag	—	1919	6.0	R.R.	
Oak[2]	—	Sawed	—	"	"	—	54	" " "	Eastern Division	1910	Yes	—	—	Rock	—	1917	8.3	R.R.	
Oak	—	Hewed	—	Zinc chloride	Untreated	—	71	A.T. & S.F.	Western Division	1912	Yes	—	—	Rock	—	1922	6.7	R.R.	
"	—	"	—	"	"	—	111	" " "	" " "	1911	"	—	—	"	—	1922	6.3	R.R.	
"	—	Sawed	—	"	"	—	176	" " "	" " "	1912	"	—	—	"	—	1922	7.3	R.R.	
"	—	Hewed	—	"	"	—	3369	" " "	" " "	1910	"	—	—	"	—	1922	7.9	R.R.	
"	—	Sawed	—	"	"	—	82	" " "	Kansas City Division	1910	"	—	—	"	—	1922	5.6	R.R.	
Oak	—	Hewed	—	Zinc chloride	Untreated	—	2221	A.T. & S.F.	Kansas City Division	1910	Yes	—	—	Rock	—	1922	5.8	R.R.
Oak[2]	—	"	—	"	"	—	91	" " "	Oklahoma Division	1910	"	—	—	"	—	1922	5.0	R.R.
Oak[2]	—	—	—	"	"	—	100	" " "	" " "	1912	"	—	—	"	—	1920	6.9	R.R.
Oak[2]	—	Sawed	—	"	"	—	116	" " "	Pecos Division	1913	—	—	—	—	—	1919	8.1	R.R.
Oak	—	Hewed	—	"	"	—	139	" " "	Western Division	1910	Yes	—	—	Dirt & cinders	—	1922	8.6	R.R.
Oak[2]	—	Sawed	—	Zinc chloride	Untreated	—	174	A.T. & S.F.	Western Division	1911	Yes	—	—	Dirt & cinders	—	1920	6.2	R.R.
Oak, Japanese	—	—	—	"	"	—	60	" " "	Albuquerque Division	1912	"	—	—	Volcanic	—	1922	10.0	R.R.
" "	—	—	—	"	"	—	176	" " "	" " "	1910	—	—	—	—	—	1922	8.1	R.R.
" "	—	—	—	"	"	—	328	" " "	" " "	1911	—	—	—	—	—	1925	8.3	R.R.
" "	—	—	—	"	"	—	526	" " "	" " "	1912	Yes	—	—	Volcanic	—	1925	7.7	R.R.
Oak, Japanese	—	—	—	Zinc chloride	Untreated	—	762	A.T. & S.F.	Los Angeles Division	1910	—	—	—	Gravel	—	1922	6.8	R.R.
" "	—	—	—	"	"	—	2032	" " "	" " "	1911	—	—	—	"	—	1922	6.1	R.R.
" red	—	—	—	"	"	—	100	O. & R.R.	Carroll, Iowa	1914	—	—	—	—	—	1926	6.5	F.P.L.
" "	—	—	—	"	"	—	99	" " "	Oakaloosa, Iowa	1914	—	—	—	—	—	1922	7.0	F.P.L.
" "	—	—	—	"	"	—	100	" " "	Verdi, Minn.	1918	—	—	—	—	—	1922	5.1	F.P.L.
Oak, red	—	—	—	Zinc chloride	Untreated	—	100	O. & R.V.	Wamac, Ill.	1918	—	—	—	—	—	1925	6.6	F.P.L.
Pine	—	Hewed	—	Petroleum	—	10.0	126	A.T. & S.F.	Arkansas River Division	1918	—	—	—	Rock & gravel	—	1922	3.8	R.R.
"	—	"	—	"	—	6.8	409	" " "	" " "	1913	—	—	—	" " "	—	1917	8.0	R.R.
"	—	Sawed	—	Zinc chloride	—	.51	96	" " "	New Mexico Division	1917	Yes	—	—	Rock	—	1924	6.7	R.R.
Pine, loblolly	6"x7"x8'	Sawed	Green	Zinc chloride	Untreated	—	99	O. & R.V.	Chaderon, Neb.	1918	Sellers	—	Out	Gravel	—	1922	4.3	F.P.L.
" , southern yellow	7"x8"x8'	"	—	Zinc creosote	—	5-6	547	Mo. Pac.	Lafayette to Scott, La.	1906	Q. A W.	—	"	"	—	1926	13.1	F.P.L.	Mechanical wear
" " "	7"x9"x9'	"	—	Creosote	Full cell	12	206	" "	Bithorn & Salis, La.	1907	O.S.-37	—	"	"	—	1926	13.4	F.P.L.	" "
" " "	7"x9"x9'	"	—	Zinc creosote	Alliardgroc	5-6	433	" "	" " "	1907	O.S.-37	—	"	"	—	1926	10.2	F.P.L.	" "
Redwood	—	—	—	Zinc chloride	Untreated	—	144	A.T. & S.F.	Valley Division	1916	Yes	—	—	Rock	—	1925	7.3	R.R.

[1] F.P.L. = Average life computed by Forest Products Laboratory; R.R. = Records and average life reported by railroads.

[2] Switch ties.

[3] Side track.

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
November 16, 1927.

(3) The kind of timber used.
(4) The type of track construction; that is, ballast, use of tie plates, weight of rail, whether ties were bored and adzed, etc.
(5) The density of traffic.
(6) The percentage of proper maintenance.
(7) The degree of approach to the normal age limit of treated ties.

Taking up these points individually:

(1) **Proportion of Treated and Untreated Ties:** It is perfectly obvious that a railway with a high percentage of insertions per year of untreated ties will, in the course of time, remove a higher proportion of ties from its track than a road on which the situation is reversed. In other words, this is simply stating that a treated tie will last longer than an untreated one.

(2) **The Preservative Used:** Included in this factor are the type of preservative, the quantity of preservative, and the kind of treatment. Illustrating this point briefly, experience has shown that one may reasonably expect longer life from ties treated with creosote than from the same ties treated with zinc chloride. Experience has also shown that where ties are treated after proper material inspection, proper seasoning, and carefully supervised treatment, better results are obtained than when ties are less carefully handled. Any tie renewal figures per mile for any one year will, therefore, reflect difference in length of life due to the particular points discussed under this heading. This first mentioned factor is of the utmost significance at this time because so many railroads have both zinc-treated and creosoted ties in track. Such railroads will show an apparently high annual renewal when compared with roads having a similar percentage of treated ties in track, all of which are creosoted.

The same reasoning will apply to quantity of preservative used. The greater the quantity of preservative initially injected into the ties, the greater will be the guarantee for long life.

(3) **The Kind of Timber Used:** Experience has shown that longer life will be obtained from hardwoods than from softwoods under heavy traffic. Roads with a higher percentage of treated hardwood ties in track, therefore, will usually show correspondingly lower annual renewals.

(4) **Type of Track Construction:** The length of life of treated ties is obviously dependent upon factors which influence their mechanical life. A treated tie which may be protected against decay for 30 years may be otherwise destroyed long before that time has been reached. Of the factors which are conducive to giving a maximum life, the following are the most important: the type of ballast used, the tie plates of sufficient size and thickness, adzing and boring before treatment, "S" irons and other anti-checking devices, anti-rail creepers, and the weight of rail used in relation to the traffic handled. Annual tie renewals will reflect the type of practice herein referred to even where all treated ties are used.

(5) **The Density of Traffic:** This factor is so obvious that it requires no further discussion.

Committee 7 I A W P A
XVII AREA

CROSS TIE RENEWALS PER MILE OF ALL TRACK MAINTAINED 1900-

Year	AT & SF Miles	AT & SF Ties	AT & SF 5 Yr Avg Ties	B & O Miles	B & O Ties	B & O 5 Yr Avg Ties	CB & Q Miles	CB & Q Ties	CB & Q 5 Yr Avg Ties	C & EI Miles	C & EI Ties	C & EI 5 Yr Avg Ties
1900	[illegible]	[illegible]								1 086	232	
01	[illegible]	[illegible]		[illegible]	248					[illegible]	[illegible]	
02	[illegible]	204	228	[illegible]	96					1 146	229	
03	[illegible]	[illegible]	[illegible]	[illegible]	92					1 158	188	
04	[illegible]	[illegible]	[illegible]	[illegible]	223					1 231	[illegible]	[illegible]
05	[illegible]	[illegible]	[illegible]	9 904	[illegible]	222				1 291	[illegible]	[illegible]
06	[illegible]	[illegible]	[illegible]	9 032	265	221				1 479	148	163
07	[illegible]	288	[illegible]	9 156	234	233				1 493	[illegible]	161
08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				1 509	139	161
09	[illegible]	293	267	[illegible]	264	[illegible]				1 514	121	139
1910	[illegible]	241	[illegible]	[illegible]	[illegible]	249				1 522	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	9 545	206	242				1 520	134	174
12	[illegible]	220	273	9 725	208	245				[illegible]	165	169
13	[illegible]	[illegible]	[illegible]	9 788	254	245				2 008	289	187
14	[illegible]	[illegible]	328	[illegible]	220	236	2 582	231		2 046	202	203
15	[illegible]	[illegible]	[illegible]	[illegible]	309	[illegible]	2 634	[illegible]		[illegible]	228	214
16	[illegible]	201	200	9 973	310	[illegible]	12 999	203		1 892	240	236
17	[illegible]	[illegible]	[illegible]	[illegible]	238	[illegible]	13 253	92		[illegible]	187	223
18	[illegible]	[illegible]	[illegible]	[illegible]	94	234	13 321	194	209	1 880	156	211
19	[illegible]	[illegible]	[illegible]	[illegible]	263	[illegible]	13 363	162	[illegible]	[illegible]	41	94
1920	[illegible]	[illegible]	[illegible]	[illegible]	225	[illegible]	13 365	[illegible]	166	665	102	68
21	[illegible]	[illegible]	33	10 126	229	[illegible]	13 369	177	181	1 663	63	132
22	[illegible]	[illegible]	33	[illegible]	235	225	13 420	67	176	1 654	31	121
23	[illegible]	126	[illegible]	[illegible]	201	229	[illegible]	169	171	1 662	138	119
24	[illegible]	[illegible]	[illegible]	[illegible]	132	218	[illegible]	[illegible]	96	1 661	92	109
25	[illegible]	[illegible]	[illegible]	[illegible]	200	207	13 366	52	63	1 663	86	106
26	[illegible]	[illegible]	[illegible]	10 754	190	200	13 603	[illegible]	158	1 662	112	116
27												
28												
29												
1930												

Year	CCC & StL Miles	CCC & StL Ties	CCC & StL 5 Yr Avg Ties	CM & StP (Eastern Lines) Miles	CM & StP Ties	CM & StP 5 Yr Avg Ties	CRI & P Miles	CRI & P Ties	CRI & P 5 Yr Avg Ties	DL & W Miles	DL & W Ties	DL & W 5 Yr Avg Ties
1900										2 190	216	
01				[illegible]	210					2 202	270	
02				6 617	213					2 212	201	
03				6 648	144					[illegible]	223	
04				[illegible]	121					2 309	227	229
05	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]				2 346	247	233
06	[illegible]	292		[illegible]	116	136				2 377	223	234
07	[illegible]	[illegible]		[illegible]	94	[illegible]				2 422	245	232
08	[illegible]	[illegible]		[illegible]	70	181	9 006	289		2 439	277	243
09	3 601	198	[illegible]	[illegible]	262	[illegible]	9 311	275		2 479	235	244
1910	3 654	356	[illegible]	[illegible]	[illegible]	[illegible]	9 311	246		2 500	159	229
11	3 923	368	[illegible]	10 133	194	167	9 311	269		2 614	203	229
12	3 960	316	313	10 133	163	181	9 809	209	256	2 619	231	227
13	3 973	282	314	10 550	208	[illegible]	9 911	221	243	2 644	231	228
14	4 010	269	320	10 837	[illegible]	189	10 118	243	237	2 627	259	232
15	4 001	271	[illegible]	11 021	183	[illegible]	10 044	249	237	2 683	279	234
16	4 021	212	272	11 072	251	199	10 044	232	229	2 636	[illegible]	249
17	4 090	202	245	11 100	33	93	10 065	183	224	2 663	[illegible]	233
18	4 110	205	233	11 107	288	197	10 274	135	210	2 671	121	201
19	4 173	231	219	11 112	282	208	10 234	158	192	2 673	[illegible]	180
1920	4 177	159	195	[illegible]	146	200	10 290	190	162	2 677	139	158
21	4 210	194	[illegible]	[illegible]	[illegible]	[illegible]	10 329	169	171	2 675	166	150
22	4 229	143	[illegible]	11 068	198	191	10 323	131	169	2 678	137	146
23	3 972	191	177	[illegible]	225	192	10 424	140	162	2 679	102	142
24	[illegible]	139	155	11 898	204	189	10 371	118	156	2 676	85	130
25	4 018	140	161	[illegible]	197	[illegible]	10 361	139	163	2 710	98	118
26	4 239	126	144	11 829	205	204	9 428	141	130	2 727	92	103
27												
28												
29												
1930												

Year	Gt Northern Miles	Gt Northern Ties	Gt Northern 5 Yr Avg Ties	Ills Central Miles	Ills Central Ties	Ills Central 5 Yr Avg Ties	K C Sou Miles	K C Sou Ties	K C Sou 5 Yr Avg Ties	Lehigh Valley Miles	Lehigh Valley Ties	Lehigh Valley 5 Yr Avg Ties	Mich Cent Miles	Mich Cent Ties	Mich Cent 5 Yr Avg Ties
1900	6 382	229								2 807	336		2 853	269	
01	6 467	229								2 838	301		2 976	241	
02	6 972	184								2 863	305		3 055	282	
03	7 088	169								2 893	307		3 136	237	
04	7 189	185	208							2 911	211	293	3 187	141	234
05	7 416	162	190							2 930	196	229	3 354	146	210
06	7 643	125	169							3 060	[illegible]	195	3 442	173	196
07	8 021	247	180							3 090	184	211	3 521	110	162
08	8 378	248	192							3 138	172	184	3 539	110	138
09	8 637	249	209							[illegible]	135	[illegible]	3 602	272	163
1910	[illegible]	293	231				1 186	482		[illegible]	177	[illegible]	3 609	176	168
11	8 990	188	[illegible]	8 870	290		[illegible]	432		3 199	141	[illegible]	[illegible]	289	191
12	9 150	228	238	9 428	287		1 231	294		3 245	164	170	3 625	208	210
13	9 195	237	254	9 320	288		1 261	331		3 277	287	189	3 659	305	249
14	9 609	232	250	[illegible]	266		1 273	335	[illegible]	3 313	232	196	3 738	284	252
15	10 104	229	239	9 638	233	272	1 284	354	357	3 320	289	219	3 766	139	263
16	10 074	250	235	9 761	228	260	1 289	338	338	3 384	286	242	3 684	[illegible]	256
17	10 513	144	238	9 922	179	242	1 290	240	320	3 405	178	250	3 922	227	302
18	10 676	250	241	10 003	161	217	1 290	237	[illegible]	3 396	173	234	3 928	197	280
19	10 620	253	245	10 068	198	204	1 290	273	298	3 395	195	224	3 974	144	252
1920	10 632	213	242	10 083	250	203	1 302	290	278	[illegible]	116	190	3 967	126	210
21	10 667	184	223	10 125	260	210	1 308	310	270	3 401	133	159	3 892	154	170
22	10 689	191	218	10 135	249	224	1 303	249	272	3 413	77	139	3 868	222	169
23	10 897	220	212	10 397	199	231	1 324	227	270	3 414	91	122	3 846	206	170
24	10 725	201	202	10 329	170	226	1 323	229	260	3 421	109	135	3 846	214	154
25	10 772	193	198	10 363	177	211	1 378	152	233	3 424	91	100	3 903	173	184
26	10 601	201	202	10 963	175	194	1 380	122	195	3 429	82	90	3 870	185	194
27															
28															
29															
1930															

Year	M K & T Miles	M K & T Ties	M K & T 5 Yr Avg Ties	Monon C I & L Ry Miles	Monon Ties	Monon 5 Yr Avg Ties	NYC (East) Miles	NYC (East) Ties	NYC (East) 5 Yr Avg Ties	" C (West) Miles	" C (West) Ties	" C (West) 5 Yr Avg Ties	Nor Pacific Miles	Nor Pacific Ties	Nor Pacific 5 Yr Avg Ties
1900													6 273	311	
01	2 410	404					6 178	228					6 329	314	
02	2 431	401					6 266	210					6 493	311	
03	2 580	437					6 292	207					6 638	318	
04	2 741	460					6 486	243					[illegible]	290	314
05	2 900	[illegible]	410				6 678	175	213	[illegible]	246		7 036	[illegible]	[illegible]
06	3 014	344	406				6 716	176	202	3 688	217		7 253	280	244
07	3 092	358	397				6 919	263	213	3 683	261		7 312	248	[illegible]
08	3 232	252	369				7 211	225	216	4 195	266		7 938	251	269
09	3 316	363	349	808	310		[illegible]	220	212	4 397	250	[illegible]	8 258	296	292
1910	3 401	449	362	810	257		[illegible]	244	[illegible]	4 668	230	[illegible]	8 430	292	293
11	[illegible]	466	386	829	386		7 535	229	231	4 770	260	[illegible]	8 761	284	294
12	3 722	401	[illegible]	843	355		7 562	219	225	4 949	263	258	8 858	287	282
13	3 907	342	403	851	360	342	7 768	239	239	5 013	295	264	9 282	317	295
14	3 958	324	386	856	365	353	7 860	271	245	5 036	242	262	9 422	306	[illegible]
15	4 021	325	[illegible]	858	231	347	8 000	243	249	5 010	301	273	9 636	276	294
16	4 063	382	353	857	289	326	8 054	[illegible]	240	5 013	273	275	9 678	247	[illegible]
17	4 082	235	322	897	145	278	8 099	197	235	5 069	270	276	9 789	292	288
18	4 140	209	293	903	168	240	8 248	159	223	5 131	244	[illegible]	[illegible]	230	270
19	4 196	268	276	[illegible]	80	183	[illegible]	193	209	5 175	189	258	[illegible]	220	253
1920	4 227	302	271	906	167	170	[illegible]	164	[illegible]	5 185	[illegible]	[illegible]	9 889	242	246
21	4 245	233	241	907	146	141	[illegible]	220	136	5 188	196	[illegible]	9 889	231	243
22	4 251	163	[illegible]	910	146	141	8 471	199	196	5 194	196	203	9 920	187	218
23	4 275	179	223	911	144	137	8 399	201	197	5 248	147	182	9 790	177	207
24	4 367	213	222	918	153	131	8 231	173	192	5 357	129	170	9 765	163	[illegible]
25	4 374	237	209	928	135	135	8 190	177	194	5 368	110	156	9 740	178	193
26	4 379	231	209	932	125	141	8 193	170	184	5 312	[illegible]	135	9 729	[illegible]	166
27															
28															
29															
1930															

Year	Penna Miles	Penna Ties	Penna 5 Yr Avg Ties	Soo Line (M St P & S St M) Miles	Soo Line Ties	Soo Line 5 Yr Avg Ties	Southern Pac (Atlantic Syst) Miles	Southern Pac (Atl) Ties	Southern Pac (Atl) 5 Yr Avg Ties	Southern Pac (Pacific Syst) Miles	Southern Pac (Pac) Ties	Southern Pac (Pac) 5 Yr Avg Ties	Union Pacific Miles	Union Pacific Ties	Union Pacific 5 Yr Avg Ties
1900	14 793	293					3 501	261		[illegible]	236		3 078	261	
01	15 143	291					3 681	270		7 282	243		3 076	242	
02	15 981	273					3 753	293		7 392	252		4 007	229	
03	16 751	244					3 847	269		[illegible]	196		3 981	166	
04	17 330	[illegible]	264				4 036	197	269	7 674	187	223	4 044	303	244
05	17 822	279	261				[illegible]	[illegible]	[illegible]	7 934	172	211	4 064	[illegible]	[illegible]
06	18 527	241	251				4 168	339	266	8 012	273	217	4 182	374	272
07	18 845	267	250				4 343	288	259	8 180	197	206	4 386	317	289
08	18 963	198	240				[illegible]	344	[illegible]	8 418	324	233	4 599	256	306
09	19 016	262	249				4 401	234	267	8 677	218	238	4 924	253	296
1910	19 508	240	242				[illegible]	[illegible]	278	8 907	240	251	5 063	267	[illegible]
11	20 083	231	240				4 504	[illegible]	263	9 067	247	[illegible]	5 291	246	263
12	20 215	290	[illegible]				4 513	249	272	9 401	[illegible]	230	5 485	171	[illegible]
13	20 441	261	256	4 977	258		4 556	211	[illegible]	9 234	193	225	5 617	231	234
14	20 578	292	264	5 112	[illegible]		4 613	295	284	9 488	205	222	5 676	248	[illegible]
15	20 686	[illegible]	278	5 279	298		4 694	364	303	9 556	232	[illegible]	5 685	[illegible]	[illegible]
16	20 829	267	289	5 289	196		4 767	367	[illegible]	[illegible]	[illegible]	221	5 722	252	[illegible]
17	22 524	212	273	5 300	272	[illegible]	4 836	196	303	10 368	188	212	5 815	196	[illegible]
18	23 003	174	256	5 331	207	235	4 879	218	291	10 434	244	223	5 984	[illegible]	[illegible]
19	23 300	211	240	5 331	266	[illegible]	4 865	[illegible]	265	10 568	251	[illegible]	6 024	185	[illegible]
1920	25 085	[illegible]	217	5 375	259	[illegible]	4 929	348	[illegible]	10 492	[illegible]	[illegible]	6 034	216	226
21	25 112	232	206	5 504	342	266	4 992	391	292	10 508	245	239	6 056	184	196
22	25 102	232	210	5 514	301	281	4 999	319	[illegible]	10 567	214	244	6 167	203	[illegible]
23	25 291	211	218	5 520	323	303	4 988	294	332	10 777	216	238	6 227	195	195
24	25 348	[illegible]	211	5 520	332	318	5 013	265	337	12 869	204	229	6 282	215	201
25	25 408	207	212	[illegible]	[illegible]	[illegible]	6 016	238	[illegible]	12 954	244	225	6 293	214	202
26	25 408	204	206	5 552	294	315	[illegible]	217	[illegible]	[illegible]	246	225	6 371	208	[illegible]
27															
28															
29															
1930															

Year	C R R of N J Miles	C R R of N J Ties	C R R of N J 5 Yr Avg Ties	Reading Miles	Reading Ties	Reading 5 Yr Avg Ties	Missouri Pacific Miles	Missouri Pacific Ties	Missouri Pacific 5 Yr Avg Ties	Miles	Ties	5 Yr Avg Ties	TOTALS FOR ALL ROADS Miles	No of Roads	Ties per Mile	5 Yr Avg Ties
1900	1 316	218											59 509	16	264	
01	[illegible]	[illegible]											[illegible]	16	234	
02	1 340	266											90 416	16	238	
03	1 354	[illegible]											92 385	16	229	
04	[illegible]	[illegible]	236										95 635	[illegible]	223	242
05	1 390	[illegible]	278										105 477	[illegible]	222	235
06	1 372	[illegible]	264										108 634	[illegible]	229	230
07	1 403	[illegible]	[illegible]										111 193	18	247	232
08	[illegible]	[illegible]	251										123 529	19	245	235
09	1 434	259	248										[illegible]	20	254	[illegible]
1910	1 464	242	231										[illegible]	21	239	243
11	1 491	204	[illegible]	[illegible]	250		[illegible]	[illegible]					[illegible]	24	262	249
12	1 531	230	234	3 005	227		9 383	408					159 016	24	257	251
13	1 569	240	233	3 032	325		9 451	385					[illegible]	25	262	[illegible]
14	1 612	224	226	3 042	267		9 444	394					[illegible]	26	256	[illegible]
15	1 633	169	215	[illegible]	290	294	9 446	[illegible]	392				183 465	26	268	261
16	1 665	136	206	3 388	192	[illegible]	9 406	[illegible]	378				186 012	26	253	[illegible]
17	1 681	127	187	3 426	170	230	9 329	329	362				[illegible]	26	[illegible]	[illegible]
18	1 713	127	169	3 463	166	219	9 353	260	336				191 693	26	198	[illegible]
19	1 745	132	146	3 474	153	196	[illegible]	[illegible]	320				192 660	26	[illegible]	227
1920	1 749	112	137	[illegible]	126	163	[illegible]	[illegible]	326				[illegible]	26	209	[illegible]
21	1 734	181	[illegible]	3 483	164	158	9 333	[illegible]	300				195 332	26	212	[illegible]
22	1 743	142	139	3 484	130	154	9 474	300	295				[illegible]	26	201	[illegible]
23	[illegible]	116	137	3 487	180	162	9 491	263	290				[illegible]	26	[illegible]	[illegible]
24	1 749	133	137	3 493	189	[illegible]	9 502	327	299				[illegible]	26	[illegible]	[illegible]
25	1 751	[illegible]	[illegible]	3 500	197	[illegible]	9 600	[illegible]	301				[illegible]	26	[illegible]	[illegible]
26	1 753	85	118	3 500	[illegible]	[illegible]	9 714	280	299				[illegible]	26	[illegible]	187
27																
28																
29																
1930																

[illegible]	[illegible]	807	1900	[illegible]	1910	1913	1922	1914	1914	1912	1904	1910	1913	1913	1920	1910	1906	1916					
[illegible]	2.60	2.97	2.330	2.808	2.830	2.828	2.613	2.907	2.925	2.930	2.786	2.875	2.970	3.040	2.976	2.935	3.000	2.800	2.822	2.918	2.803	2.413	2.882
1925	32	34	30	99	32	65	59	41	90	84	75	95	89	100	61	91	36	90	22	38	95	61	
26	36	35	100	99	99	68	100	54	99	32	93	100	94	100	96	94	94	69	97	29	68	81	100
1924	52	67	56	63	60	80	82	80	55	70	63	42	85	52	44	9	44	57	64				
25	96	67	36	65	63	80	83	85	74	62	72	60	73	30	56	92	54	30	10	40	62	70	
26	63	72	39	69	63	65	67	30	75	65	75	76	96	61	90	30	30	14	41	64	72	60	

*5 Year Average Columns 5 Years ending year shown

(6) **The Percentage of Proper Maintenance:** When a tie no longer performs the function for which it is intended, and the adjoining ties are compelled to carry more than their share of the load, the life of such adjoining ties is materially reduced. Such a track is usually called "under-maintained." Where such a condition of under-maintenance exists in any one or more years, the result will be a showing of low tie renewals per mile, but it will also cause an abnormally high annual insertion in subsequent years. While this condition is not usual, it nevertheless is a factor which must be taken into consideration in interpreting any one year's tie renewals.

(7) **The Degree of Approach to the Normal Age Limit of Treated Ties:** While treated ties will have a very much longer life than untreated ties, there is a definite limit even to their life. The actual life will be determined by the variability inherent in wood, the type of treatment, and the numerous factors above mentioned affecting the mechanical service. Of a given number of treated ties inserted in any one year, a certain small number will come out rather rapidly. There will then be the larger percentage with a considerably longer life, and again a very small percentage with an extreme life. Each year's insertions will have a definite cycle of renewal. One may therefore, anticipate that after a railroad has inserted a considerable percentage of treated ties for a term of years, the renewals per mile will drop until the average life of that particular group of ties has been reached, after which the renewals per mile per year will rise again. The greatest drop will naturally occur on those roads which have inserted 100 per cent treated ties each year for a term of years; it will be relatively less for roads in which the percentage insertions of treated ties has been less than 100 per cent. There has been much study given to the probable nature of these drops and rises. The curves of various types which have resulted from these studies all indicate the probability of this fall and rise. It would appear, therefore, that after a railroad has had treated ties in track for a certain term of years, there should be a relatively rapid reduction in the number of ties inserted per mile, but that this reduction will be followed by an increased insertion of ties per mile, which will become more or less constant, provided the treated tie insertions and the conditions of use of the ties remain constant.

For a proper understanding of the significance of the figures presented in the table of tie renewals per mile, it is, therefore, obviously necessary that the detailed history of tie insertions and practice of any particular railroad be known, because all of the factors above referred to have a bearing on the ultimate showing.

Appendix D

(4) MARINE PILING INVESTIGATIONS USED FOR MARINE CONSTRUCTION

Dr. Hermann von Schrenk, Chairman, Sub-Committee; William G. Atwood, C. S. Burt, G. F. Eberly, Andrew Gibson, W. H. Kirkbride.

The Sub-Committee submits a report on the recent inspections of the long-time test pieces prepared by the Chemical Warfare Service, some of its own members, the Army and Navy and other co-operators. This report is submitted as information.

I. IMMUNE TIMBER AND MECHANICAL PROTECTION

The timbers included in this group are all indigenous to foreign countries. Not all specimens on which reports were submitted last year are included for various reasons, but it is expected that in another year a more complete report can be submitted.

The test pieces with scupper nail protection placed at the Pearl Harbor Naval Station are practically destroyed. The pieces are heavily attacked by *teredo* and *limnoria* and have eroded the wood to such a depth that many of the nails have dropped out.

Location of tests and inspection reports follow:

ANGELIQUE *(Dicorynia paraënsis, Benth)*

New York, New Haven & Hartford Railroad

Slades Ferry, Conn. Installed July 17, 1923. No attack to November 7, 1927.

Southern Pacific Company

Galveston, Texas. Installed July 11, 1923. No sign of attack in September, 1927.

Florida East Coast Railway

St. Augustine, Fla. Installed July 31, 1923. No attack in evidence in October, 1927.

Panama Canal

Miraflores, C. Z. Installed September 17, 1923. No evidence of attack in October, 1926.

MANBARKLAK *(Lecythis ollaria, L)*

New York, New Haven & Hartford Railroad

Slades Ferry, Conn. Installed July 17, 1923. No attack to November 7, 1927.

Southern Pacific Company

Galveston, Texas. Installed July 11, 1923. No attack to September, 1927.

San Francisco, Cal. Installed January 5, 1924.

Florida East Coast Railway

Key West, Fla. Installed August 5, 1923. The *limnoria* attack previously reported on this specimen has apparently increased in in-

tensity and in October, 1927, had reached a depth of about one inch (Fig. 1).

Fig. 1—Manbarklak Blocks, 4 Years' Test at Key West, Fla.

Panama Canal

Miraflores, C. Z. Installed September 13, 1923.

Greenheart *(Nectanda rodioi, Schomb)*

No reports have been received on these specimens this year but their condition was such in 1926 that they are probably destroyed by this time.

Turpentine Wood *(Syncarpia laurifolia, Tenore)*

New York, New Haven & Hartford Railroad

Slades Ferry, Conn., and Warren, R. I. Installed July 14, 1924. A few shallow shipworm burrows were found in the sapwood in 1926, and in November, 1927, the specimen at Slades Ferry contained 60 holes and the one at Warren a smaller number.

Florida East Coast Railway

Key West, Fla. Installed June 10, 1924. A few shallow shipworm burrows were found in 1926.

Seaboard Air Line Railway

Seddon Island, Fla. Installed June 4, 1924. Slight sapwood attack by shipworms in 1926. Specimen lost during a storm in 1927.

U. S. District Engineer, Charleston, S. C.

Castle Pinckney, S. C. Installed June 24, 1924. A slight attack in the sapwood was found in December, 1924. In October, 1927, there were a large number of holes, some of them containing borers 4 to 5 inches long, but in no place had they penetrated the specimen more than ¼ to ½ inch.

II. CHEMICAL WARFARE SERVICE

The standard sets of test specimens prepared by the Chemical Warfare Service consisted of three pieces, each numbered and treated as indicated below:

No. 1—1 per cent ammoniacal solution of copper carbonate in water.

No. 2—1 per cent Diphenalamine chlorarsine in creosote.

No. 3—0.75 per cent Diphenalamine chlorarsine and 0.5 per cent phenyldichlorarsine in fuel oil.

New York, New Haven & Hartford Railroad

Warren, R. I. Installed May 15, 1925. No attack to October, 1926, and none to November 7, 1927.

Southern Pacific Company

Oakland Pier. Installed July 21, 1925. Untreated control piece completely destroyed. No attack on any treated specimens in October 10, 1927.

Ferry Slip, Port Costa, Cal. Installed July 22, 1925. In 1926 the untreated control piece was destroyed and the treated pieces were still intact and the control piece placed in 1926 showed only a light attack.

Florida East Coast Railway

Key West, Fla. Installed September 21, 1925. The untreated control pieces were found to be destroyed and were replaced in 1926, while none of the treated pieces showed any attack. In October, 1927, the control pieces were again found to be destroyed and the treated pieces slightly eroded by *limnoria.*

Naval Air Station

Pensacola, Fla. Installed June 5, 1925. In September, 1926, the control pieces were found to be destroyed and the treated pieces unattacked. In October, 1927, the control piece had again been destroyed and the treated pieces were still intact.

Naval Station

Pearl Harbor, H. I. Installed August 17, 1925. The test rack on the Torpedo Pier has been lost. The report on the rack on the Coaling Wharf is as follows:

Control Piece heavily attacked

No. 1—Soft and spongy with some indication of attack. Heavily encrusted.

No. 2—No attack and practically no encrustation.

No. 3—Heavily encrusted and attacked by limnoria.

It is probable that Nos. 1 and 2 have been reversed in this report.

Puget Sound Navy Yard

Bremerton, Wash. Installed October 14 and November 3, 1925. Inspected September 25, 1926, and October 4, 1927. In 1926 the control pieces were heavily attacked and the untreated pieces showed no sign of attack. There were three untreated specimens and the set of 3 treated pieces under Pier 4, October, 1927, treated piece No. 1 was covered in spots with barnacles equal to 3 per cent of the surface, while all others were heavily encrusted. The untreated controls were practically destroyed by borers and were replaced, while none of the treated pieces were attacked, but the No. 3 piece had softened so that a knife blade easily penetrated it about ¾ inches (Fig. 2).

A second test set under Pier 8 showed the same results except that barnacles covered about 6 per cent of the area of the No. 1 treated piece. All others were heavily encrusted.

Fig. 2—Untreated Control Piece, in Water One Year, Split Open. Bremerton, Washington.

Coco Solo, C. Z.

Submarine Base. Set "A" installed July 23 and set "B," Aug. 11, 1925. The inspection of Sept. 3, 1926, showed heavy attack on the control pieces and none on the treated pieces, with practically no encrustation on the No. 1 pieces. Inspection of Oct. 10, 1927, Set "A" showed very slight encrustation on the No. 1 piece and heavy encrustation on the others. None of the treated pieces were attacked but the control piece was destroyed. Set "B" was in the same condition.

U. S. District Engineer, Charleston, S. C.

Castle Pinckney, S. C. Installed, May 12, 1925. The control pieces were found to be destroyed on October 14, 1925, were replaced, destroyed again by September, 1926, and again in October, 1927. The treated pieces were not found to be attacked at any of these inspections except that in October, 1927, one of the two No. 1 pieces was slightly scratched in one or two places by borers.

Bureau Lighthouses

San Juan, P. R. Installed July 1, 1925. Inspections later in 1925 and in August, 1926, showed heavy attack on control pieces, practically no encrustation on the No. 1 treated pieces and an incipient *limnoria* attack on one of the No. 3 pieces. Inspection of September 28, 1927, showed No. 1 pieces still intact and relatively free from encrustation, No. 2 pieces free from attack but heavily encrusted, while both No. 3 pieces had been eroded to a depth of about ¾ inches by *limnoria* (Fig. 3).

Fig. 3—Test Sets at San Juan, Porto Rico.

U. S. Quartermaster Corps

Manila, P. I. Installed June 2, 1925. The following results of inspection are reported:

August 6, 1926, changes not noticeable in treated blocks. Untreated blocks attacked.

January 3, 1927. Slight attack by borers on treated blocks. Untreated blocks partly destroyed.

May 21, 1927. Treated blocks show several ⅛ inch holes by borers. Untreated lauan blocks destroyed.

September 26, 1927. No. 2 piece showed no action by borers but was completely covered by barnacles. No. 3 piece showed action by borers in the form of several ¼ inch holes and was also completely covered by barnacles. The piece marked No. 1 was lost on account of the breaking of bolts in the cage.

Chemical Warfare Service

Beaufort, N. C. Installed June 13, 1925. These test racks carried a large number of specimens treated with other materials than those men-

tioned above. Most of them were lost because of the destruction of a part of the wharf to which they were attached and only six specimens were recovered. None of them have been attacked to date. These pieces were treated with the following materials:

No. 20-2 Copper orthonitro benzoate in creosote
No. 24-2 Mercury benzoate in creosote
No. 25-2 Mercury resinate in creosote
No. 35-2 Mercury stearate in creosote
No. 50-2 Diphenalaminechlorarsine in creosote

A set of posts treated with diphenalaminechlorarsine in equal parts petroleum, tar oil and crude water gas tar are also unattacked.

III. EXPERIMENTS WITH CREOSOTES

A full report on the Forest Service experiments was included in the 1927 report of this Committee and it is thought unnecessary to include it this year. It is hoped that it may be included in 1929.

COMMITTEE EXPERIMENTS

The test specimens prepared by impregnation with various creosotes as described in previous reports have been inspected with the following results:

Report on Inspection October 10, 1927, of Specimens Installed in San Francisco Bay on Request of Dr. Hermann von Schrenk

Barrett Manufacturing Company Material

Placed Station B, Pier 7, San Francisco, January, 1923. Moved to Biological Station, Oakland Pier, c/o S. P. Co., December, 1925. No attack except slightly by *limnoria*.

Gate No.	Specimen No.	Treatment	Condition October 10, 1927
B 4	P 1	Coke oven original oil.	P 1 intact.
	2	ditto, solids removed.	P 2, 3 and 4 slightly eroded by *limnoria* on ends; sides slightly attacked near ends.
	3	ditto, acids removed.	
	4	ditto, bases removed.	
B 5	P 5	Coke, minus residue above 360° C.	All slightly eroded by *limnoria* on ends. P 5 also on sides next to end. P 8 slightly worse.
	6	Coke, minus fraction 230-270° C.	
	7	Coke, minus fraction up to 230° C.	
	8	Coke, minus fraction 270-360° C.	
B 6	P 9	Vertical retort original oil.	All slightly eroded by *limnoria* on ends; sides intact.
	10	ditto, minus solids.	
	11	ditto, minus acids.	
	12	ditto, minus bases.	
B 7	P 13	ditto, minus residue above 360° C.	All slightly eroded by *limnoria* on ends; sides have merest traces.
	14	ditto, minus fraction 230-270° C.	
	15	ditto, minus fraction up to 230° C.	
	16	ditto, minus fraction 270-360° C.	
B 8	F 1		All slightly eroded on ends. On sides attack confined to line across specimens where gate had rubbed against a submerged brace.
	2	Coke oven oils duplicating B 4 in identical order.	
	3		
	4		

Gate No.	Specimen No.	Treatment	Condition October 10, 1927
B 9	F 5 6 7 8	Coke oven oils duplicating B 5 in identical order.	All slightly eroded on ends. Only traces on sides.
B 10	F 9 10 11 12	Vertical retort oils duplicating B 6 in identical order.	All show slight erosion on both ends and sides.
B 11	F 13 14 15 16	Vertical retort oils duplicating B 7 in identical order.	Erosion on all ends, not severe but deeper than on preceding. On sides generally light but deeper in spots. P 13 and P 16 worse than P 14 and P 15.

NOTE: A careful inspection of these test pieces shows no appreciable change in condition since last inspection one year ago.

REPORT OF INSPECTION OCTOBER 11, 1927, OF SPECIMENS FURNISHED BY CHEMICAL WARFARE SERVICE AND INSTALLED IN SAN FRANCISCO BAY ON REQUEST OF DR. HERMANN VON SCHRENK

Gate 25-1A

Installed at Biological Station, Oakland Pier, July 21, 1925.

No. 1—1% Ammoniacal Copper Carbonate.
No. 2—Creosote plus 1% Diphenylamine Chlorarsine.
No. 3—Fuel Oil plus .75% Diphenylamine Chlorarsine plus .5% Phenyl Dichlorarsine.
No. 4—Untreated control piece. Completely destroyed and not replaced.

Condition October 10th, 1927: No signs of attack on treated pieces.

Gate 25-1B

Installed at Ferry Slip, Port Costa, July 22nd, 1925.
Duplicate of Gate 25-1A.

Condition October 11, 1927: Original bait piece was completely destroyed. This bait piece was replaced during last year's inspection and the new piece shows but slight attack by *Teredo navalis*. None of the borers exceeded one inch in length and the number attacking did not exceed ten. Think this mild attack due to the fact that this year has been of heavy rainfall which has resulted in a reduced salinity of the water.

1927 Report on Test Piles

The following tables, 1-A to 1-D, give the 1927 condition of four sets of test piles driven in 1919 and 1920 at Seattle, Tiburon in San Francisco Bay, San Pedro and San Diego. Each set originally consisted of seven piles, including the following:

3 Old Creosoted Fir Piles originally driven in 1890.....Table 1-A
1 Old Creosoted Fir Pile originally driven in 1901.....Table 1-B
2 New Freshly Creosoted Fir Piles.....Table 1-C
1 New Untreated Fir Pile.....Table 1-D

The untreated piles were destroyed in three or four years as shown in Table 1-D, leaving six piles in each set.

The set at San Diego was exposed for test by the A. T. & S. F. Railway in their Wharf No. 63, until this wharf was dismantled in July of 1925. After being repaired they were redriven by the Southern Pacific Company at Long Beach, California, and the test continued.

TEST PILES—TABLE 1-A

Creosoted Fir Piles from Southern Pacific Company Old Long Wharf Dock "A," Oakland. Originally Driven in 1890. Pulled in 1919 and Redriven Elsewhere. Exposed to Marine Borer Attack Thirty-seven Years to Date.

Redriven for Test				*1927 Inspection*	
Mark	*Date*	*Railroad*	*Location*	*Remarks*	*Borers*
A-6	1920	NP Ry Co	Seattle	No attack to date	.....
A-8	1920	"	"	Slight *teredo* attack in knot and in small check; otherwise pile OK	.....
A-32	1920	"	"	No attack to date	.....
A-19	1919	NWP Ry	Tiburon*	"	.....
A-28	1919	"	" *	"	.....
A-29	1919	"	" *	"	.....
A-5	1919	SP Co	San Pedro	Slight *limnoria* erosion in 3 spots; no further attack since last year	*Limnoria*
A-20	1919	"	"	Slight *limnoria* erosion; no further attack since last year	*Limnoria*
A-34	1919	"	"	2 holes 3 inches deep by *limnoria*	*Limnoria*
A-2	1920	AT&SF Ry	San Diego	Pulled, 1925	.....
A-2	1925	SP Co	Long Beach	Holes attacked by *limnoria* repaired 1925 and attack stopped; no further attack to date	*Limnoria*
A-7	1920	AT&SF Ry	San Diego	Pulled, 1925	.....
A-7	1925	SP Co	Long Beach	Holes attacked by *limnoria* repaired 1925 and attack stopped; no further attack to date	*Limnoria*
A-33	1920	AT&SF Ry	San Diego	Pulled, 1925	*Limnoria*
A-33	1925	SP Co	Long Beach	Holes attacked by *limnoria* repaired 1925 and attack stopped; no further attack to date	

*San Francisco Bay.

TEST PILES—TABLE 1-B

Creosoted Fir Piles From Southern Pacific Company Old Long Wharf Dock "E," Oakland. Originally Driven in 1901. Pulled in 1919 and Redriven Elsewhere. Exposed to Marine Borer Attack Twenty-six Years to Date.

Redriven for Test				*1927 Inspection*	
Mark	*Date*	*Railroad*	*Location*	*Remarks*	*Borers*
E-46	1920	NP Ry Co	Seattle	Slight *teredo* attack in small check; otherwise pile OK	.....
E-42	1919	NWP Ry	Tiburon*	2 holes attacked by *limnoria* repaired in 1924; no further attack to date	*Limnoria*
E-38	1919	SP Co	San Pedro	Slight attack by *limnoria*	*Limnoria*
E-50	1920	AT&SF Ry	San Diego	Pulled in 1925	.....
E-50	1925	SP Co	Long Beach	Old scorings by *limnoria* repaired in 1925; slight *limnoria* attack during past year	*Limnoria*

*San Francisco Bay.

TEST PILES—TABLE 1-C

Freshly Creosoted Fir Piles, Exposed to Marine Borer Attack Seven Years to Date.

Driven for Test				*1927 Inspection*	
Mark	*Date*	*Railroad*	*Location*	*Remarks*	*Borer*
47	1920	NP Ry Co	Seattle	No attack to date	.....
	1920	NP Ry Co	Seattle	*Teredo* in 3 small checks below low tide	*Teredo*
43	1919	NWP Ry	Tiburon*	No attack to date	.....
44	1919	"	"	No attack to date	.....
40	1919	SP Co	San Pedro	No attack to date	.....
41	1919	"	"	No attack to date	.....
51	1920	AT&SF	San Diego	Pulled, 1925	.....
51	1925	SP Co	Long Beach	Holes attacked by *limnoria* repaired 1925 and attack stopped; no further attack to date	*Limnoria*
52	1920	AT&SF Ry	San Diego	Pulled, 1925	.....
52	1925	SP Co	Long Beach	Holes attacked by *limnoria* repaired in 1925; attack stopped; no further attack to date	*Limnoria*

*San Francisco Bay.

TEST PILES—TABLE 1-D

Untreated Fir Piles. Exposed to Marine Borer Attack.

Driven for Test				*1927 Inspection*	
Mark	*Date*	*Railroad*	*Location*	*Remarks*	*Borer*
49	1920	NP Ry Co	Seattle	Broken off at mud line, 1923	*Limnoria* *Bankia*
45	1919	NWP Ry	Tiburon*	Broken off at mud line, 1923	*Limnoria* *Bankia* *Teredo* *Navalis*
39	1920	AT&SF Ry	San Diego	Broken off at mud line, 1923	*Limnoria* (Probably) *Bankia*

*San Francisco Bay.

MISCELLANEOUS TESTS

The Northern Pacific Railway has been making some interesting tests with comparatively inexpensive treatments. Four series of blocks were treated, each series containing five blocks. Treatments were as follows:

(A) Lowry Process, Crude oil 10.7 lb. per cu. ft.
(B) Lowry Process, 50 per cent Creosote, 50 per cent crude oil 7.6 lb. per cu. ft.
(C) Rueping Process, 50 per cent Creosote, 50 per cent crude oil 7.1 lb. per cu. ft.
(E) Rueping Process, Creosote 7.8 lb. per cu. ft.

These blocks were immersed at Pier No. 1, Seattle, on November 13, 1926, and inspected one year later. No *teredo* were found except in block B, which contained one small animal. This test is inconclusive as yet, but it is interesting to note that the crude oil block shows no attack after one year, as was the case in a previous test by the Northern Pacific.

Seventh Interim Report of the British Sea Action Committee

Laboratory tests to determine relative toxicity were continued and the results obtained by the U.S. Chemical Warfare Service were further checked. New sets of test timbers were impregnated with the four arsenic compounds being used. These sets are being given service tests at Singapore and Colombo.

Tests at Lowestoft for three years show good results for the arsenical compounds, but many of the test pieces have been lost.

No attack on treated pieces has yet appeared at Colombo except from martesia. It does not appear that the arsenical compounds are any more effective against *martesia* than creosote. In fact, no impregnating material so far tested by either the British or American Committees has been found

to be effective against these animals. Fortunately, they are found only in tropical or semi-tropical harbors.

The British Committee are studying the corrosion of various irons and steels. Results are so far not conclusive but indications are that some metals and alloys which give good results when not constantly immersed show different results when placed below low tide. Copperized steel is one of these.

A great difference is found between the rate of corrosion at Halifax, N. S., English harbors and Colombo, Auckland, N. Z., and Singapore. The rate of corrosion in practically all specimens is much lower in the Northern harbors than in those in the tropics.

Summary

The tropical timbers containing silica continue to show high resistance to attack except at Key West where *limnoria* have made a heavy attack on manbarklak.

The results from the turpentine wood confirm previous reports. In practically all cases the thin sapwood is attacked but no serious damage is apparent.

The Chemical Warfare Service specimens are beginning to show some attack, especially the No. 3 pieces treated with two arsenical compounds in a fuel oil carrier. The No. 1 pieces continue to show resistance, not only to attack by borers but also to encrustation.

The San Francisco tests of the various creosotes are still inconclusive because practically all test pieces are not appreciably damaged.

The piles from the "Long Wharf" of the Southern Pacific at Oakland which were redriven in various harbors on the Pacific Coast have been little damaged after 37 years' service.

Recommendations

It is recommended that the work of this Sub-Committee be continued with no change of plan.

Appendix E

(5-a) TREATMENT WITH MIXTURE OF CREOSOTE AND PETROLEUM

R. S. Belcher, Chairman, Sub-Committee; J. E. Fanning, E. B. Fulks, W. R. Goodwin, L. J. Reiser, W. R. Rhodes, O. C. Steinmayer, G. C. Stephenson, T. H. Strate, J. H. Waterman.

Your Committee reported on this subject in 1924, 1925, and 1926*, the report this year being a continuation of the subject, and covers the creosote-petroleum ties in the Cleveland Test Section of the Beaumont Division of the Santa Fe, inspection of which was made by the Committee in October, 1927. Tables 1 to 25, which follow, are the result of this inspection, and

*Vol. 25, pages 862 to 895; Vol. 26, pages 102 to 209; Vol. 27, page 1000.

in these tables comparison of the various groups of these test ties is made as to kinds of wood, pounds of creosote per cubic foot of timber, pounds of mixture per cubic foot of timber, and kinds of mixture.

The rainfall on the Cleveland Test Section in 1926 was 45½ inches, and the gross tonnage over the Section was approximately 4,253,000 tons. The ties are in dirt ballast.

Comparison of kinds of wood (Table 1) indicates better results from hewn heart pine and hewn gum than from the other woods.

Comparison of results on the basis of pounds of mixture absorbed per cubic foot of timber (Table 9) indicates lowest average life to date for those ties which absorbed less than 5 pounds of mixture. As yet, no one of these groups shows greatly better results than another.

Comparison on the basis of pounds of creosote (in mixture) per cubic foot of timber (Table 17) shows lowest average life in track to date for those ties which received less than 1 pound of creosote per cubic foot. To date, however, no one group is strikingly better than another in this comparison. In both tables 9 and 17 there is considerable variation in per cent removed up to date of inspection, but this variation does not point definitely to advantage of more or less mixture or more or less creosote per cubic foot.

The comparison this year of the several mixtures in this test (Table 25) indicates somewhat better results from the one part creosote and two parts petroleum mixtures than from the one to three and one to four mixture groups. This is in line with the Committee's findings in 1923.

It should be stated in connection with all of these comparisons, that mechanical wear in its various forms is responsible to a very considerable extent for the failure of ties which have been removed, which has influenced comparative results.

Considering the 815 creosote-petroleum ties as a whole (Table 1) 154, or 18.90 per cent, have been removed from track for all causes during the 14 and 15 years they have been in track, and their average life in track up to the inspection in October was 13.88 years. There are 19 ties, or 2.33 per cent of the number inserted, which show some decay but not sufficient to make renewal necessary. It is of interest to note the following renewals each year for the past five years:

Calendar Year	*Ties*	*Per Cent*
1923	48	5.89
1924	109	13.37
1925	112	13.74
1926	130	15.95
1927	154	18.90

Recommendations

This report is submitted to the Association as information, with recommendation that the study of the subject be continued.

MIXTURE TREATED TIES - CLEVELAND, TEXAS.

(Creosote-Petroleum)

Summary

Table -1

Kind of Wood	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
Hewn Sap Pine	86	1910	1912	1	2		1		2	11		5	7	29	33.72	14.00	4	4.65
	116		1913			1	3		2	18	3	2	7	36	30.17	13.18	4	3.45
Hewn Loblolly Pine	78	1909-1910	1912	3					8	17		4	3	35	44.87	13.42	3	3.85
Hewn Shortleaf Pine	29	1909	1912						2	3			1	6	20.69	14.41	2	6.90
Hewn Longleaf Pine	22	1909	1912	2			1			1		1	2	7	31.82	13.45	0	0.00
Hewn Heart Pine	122	1910	1912	5		1				3			1	10	8.20	14.38	0	0.00
	116		1913				1			1		1	2	5	4.31	13.91	5	4.31
Hewn Oak	50	1910	1912	3			3		3	5		2		16	32.00	12.66	1	2.00
Hewn Gum	80	1910	1912	2		2						3	1	8	10.00	14.49	0	0.00
	116	1910	1913							2				2	1.72	13.95	0	0.00
	815			16	2	4	9		17	61	3	18	24	154	18.90%	13.88	19	2.33%

MIXTURE TREATED TIES - CLEVELAND, TEXAS
(Creosote-Petroleum)

Comparison of Results to Date-Pounds of Mixture per Cubic Foot of Timber Avr.

Amount Mixture per cubic foot	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
HEWN SAP PINE - Table 2																		
Less than 5 lbs.	9	1910	1912						1			2	2	5	55.56	14.33	0	0.00
	2	1910	1913											0	0.00	14.00	0	0.00
5 to 7 lbs	32	1910	1912									3	1	4	12.50	14.91	3	9.37
	41	1910	1913			1	1		1	6		1	4	14	34.15	13.78	3	7.32
7 to 8 lbs	4	1910	1912							1				1	25.00	14.25	0	0.00
	36	1910	1913						1	7			1	9	25.00	13.31	0	0.00
8 to 10 lbs	8	1910	1912							2			1	3	37.50	14.25	0	0.00
	32	1910	1913				2			5	3	1	2	13	40.62	12.94	2	6.25
10 to 15 lbs	32	1910	1912	1	2		1		1	7			3	15	46.87	13.16	0	0.00
	5	1910	1913											0	0.00	14.00	0	0.00
15 lbs & over	1	1910	1912							1				1	100.00	12.00	0	0.00
	202			1	2	1	4		4	29	3	7	14	65	32.18	13.56	8	3.96
HEWN LOBLOLLY PINE - Table 3																		
Less than 5 lbs.	0													0				
5 to 7 lbs	0													0				
7 to 8 lbs	0													0				
8 to 10 lbs	0													0				
10 to 15 lbs	2	1910	1912						1					1	50.00	13.00	0	0 00
15 lbs & over	76	1910	1912	3					7	17		4	3	34	44.74	13.38	3	3.95
	78			3					8	17		4	3	35	44.87	13.42	3	3.85
HEWN SHORTLEAF PINE - Table 4																		
Less than 5 lbs	0													0				
5 to 7 lbs	0													0				
7 to 8 lbs	0													0				
8 to 10 lbs	1	1910	1912											0	0.00	15.00	0	0.00
10 to 15 lbs	12	1910	1912						1	1				2	16.67	14.42	2	16.67
15 lbs & over	16	1910	1912						1	2			1	4	25.00	14.37	0	0.00
	29								2	3			1	6	26.90	14.41	2	6.90

MIXTURE TREATED TIES - CLEVELAND, TEXAS
(Creosote-Petroleum)

Comparison of Results to Date-Pounds of Mixture per Cubic Foot of Timber

Amount Mixture per cubic foot	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
HEWN LONGLEAF PINE - Table 5																		
Less than 5 lbs	3	1910	1912	1						1				2	66.67	10.00	0	0.00
5 to 7 lbs.	3	1910	1912											0	0.00	15.00	0	0.00
7 to 8 lbs.	4	1910	1912	1									2	3	75.00	12.00	0	0.00
8 to 10 lbs.	4	1910	1912				1					1		2	50.00	13.25	0	0.00
10 to 15 lbs.	7	1910	1912											0	0.00	15.00	0	0.00
15 lbs & over	1	1910	1912											0	0.00	15.00	0	0.00
	22			2			1			1		1	2	7	31.82	13.45	0	0.00
HEWN HEART PINE - Table 6																		
Less than 5 lbs	3	1910	1912											0	0.00	15.00	0	0.00
	5	1910	1913											0	0.00	15.00	0	0.00
5 to 7 lbs	12	1910	1912											0	0.00	15.00	0	0.00
	39	1910	1913							1		1	1	3	7.69	14.90	1	2.56
7 to 8 lbs	10	1910	1912											0	0.00	15.00	0	0.00
	35	1910	1913										1	1	2.86	15.00	2	5.71
8 to 10 lbs	31	1910	1912	1		1				1			1	4	12.90	14.29	0	0.00
	29	1910	1913				1							1	3.45	13.79	2	6.90
10 to 15 lbs	50	1910	1912	4						2				6	12.00	13.92	0	0.00
	8	1910	1913											0	0.00	14.00	0	0.00
15 los and over	16	1910	1912											0	0.00	15.00	0	0.00
	238			5		1	1			4		1	3	15	6.30	14.15	5	2.10
HEWN OAK - Table 7																		
Less than 5 lbs	34	1910	1912	3			3		3	4		2		15	44.12	12.50	1	2.94
5 to 7 lbs	14	1910	1912							1				1	7.14	14.79	0	0.00
7 to 8 lbs	1	1910	1912											0	0.00	15.00	0	0.00
8 to 10 lbs	1	1910	1912											0	0.00	15.00	0	0.00
10 to 15 lbs	0													0				
15 lbs & over	0													0				
	50			3			3		3	5		2		16	32.00	13.34		2.00

MIXTURE TREATED TIES - CLEVELAND, TEXAS
(Creosote-Petroleum)

Comparison of Results to Date-Pounds of Mixture per Cubic Foot of Timber

Amount Mixture per cubic foot	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
HEWN GUM - Table 8																		
Less than 5 lbs	14	1910	1912	2		1						1		4	28.57	12.71	0	0.00
	7	1910	1913											0	0.00	14.00	0	0.00
5 to 7 lbs	18	1910	1912			1						2	1	4	22.22	14.51	0	0.00
	27	1910	1913							1				1	3.70	13.89	0	0.00
7 to 8 lbs	11	1910	1912											0	0.00	15.00	0	0.00
	26	1910	1913											0	0.00	14.00	0	0.00
8 to 10 lbs	18	1910	1912											0	0.00	15.00	0	0.00
	40	1910	1913											0	0.00	14.00	0	0.00
10 to 15 lbs	17	1910	1912											0	0.00	15.00	0	0.00
	16	1910	1913							1				1	6.25	13.81	0	0.00
15 lbs & over	2	1910	1912											0	0.00	15.00	0	0.00
	196			2		2				2		3	1	10	5.10	14.17	0	0.00
ALL WOODS - Table 9																		
Less than 5 lbs.	63	1910	1912	6		1	3		4	5		5	2	26	41.25	12.89	1	1.59
	14	1910	1913											0	0.00	14.00	0	0.00
5 to 7 lbs.	79	1910	1912			1				1		5	2	9	11.39	14.76	3	3.80
	107	1910	1913			1	1		1	8		2	5	18	16.82	13.60	4	3.74
7 to 8 lbs.	30	1910	1912	1						1			2	4	13.33	14.50	0	0.00
	97	1910	1913						1	7			2	10	10.31	13.74	2	2.06
8 to 10 lbs.	63	1910	1912	1		1	1			3		1	2	9	14.29	14.44	0	0.00
	101	1910	1913				3			5	3	1	2	14	13.86	13.60	3	2.97
10 to 15 lbs.	120	1910	1912	5	2		1		3	10			3	24	20.00	13.97	3	2.50
	29	1910	1913							1				1	3.45	13.90	0	0.00
15 lbs & over	112	1910	1912	3					8	20		4	4	39	34.82	13.82	3	2.69
	467	1910	1912	16	2	3	5		15	40		15	15	111	23.77	14.03	10	2.14
	348	1910	1913			1	4		2	21	3	3	9	43	12.36	13.68	9	2.59
	815			16	2	4	9	0	17	61	3	18	24	154	18.90	13.18	19	2.33

MIXTURE TREATED TIES-CLEVELAND, TEXAS
(Creosote-Petroleum)

Comparison of Results to Date-Pounds of Creosote per Cubic Foot of Timber

Amount Creosote per cubic foot	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
HEWN SAP PINE - Table 10																		
Less than 1 lb.	8	1910	1912						1			2	2	5	62.50	14.25	0	0.00
	1	1910	1913											0	0.00	14.00	0	0.00
1 to 2 lbs	33	1910	1912							3		3	2	8	24.24	14.33	3	9.09
	59	1910	1913			1	1		2	12			4	20	33.90	13.03	2	3.39
2 to 3 lbs	44	1910	1912	1	2		1		1	7			3	15	34.09	13.41	1	2.27
	45	1910	1913							5	2	2	2	11	24.44	13.09	2	4.44
3 to 4 lbs	1	1910	1912							1				1	100.00	12.00	0	0.00
	11	1910	1913				2			1	1		1	5	45.45	12.45	0	0.00
4 to 5 lbs	0													0				
5 to 6 lbs	0													0				
6 to 7 lbs	0													0				
7 to 8 lbs	0													0				
	202			1	2	1	4		4	29	3	7	14	65	32.18	13.56	8	3.96
HEWN LOBLOLLY PINE - Table 11																		
Less than 1 lb	0													0				
1 to 2 lbs	0													0				
2 to 3 lbs	0													0				
3 to 4 lbs	6	1910	1912	1					2	1				4	66.67	11.17	1	16.67
4 to 5 lbs	31	1910	1912	2					3	10			2	17	54.84	12.87	1	3.23
5 to 6 lbs	24	1910	1912						2	3		3		8	33.33	14.58	1	4.17
6 to 7 lbs	13	1910	1912						1	3			1	5	38.46	14.00	0	0.00
7 to 8 lbs	4	1910	1912									1		1	25.00	14.75	0	0.00
	78			3					8	17		4	3	35	44.87	13.42	3	3.85
HEWN SHORTLEAF PINE - Table 12																		
Less than 1 lb	0	1910	1912											0				
1 to 2 lbs	0													0				
2 to 3 lbs	2	1910	1912											0	0.00	15.00	1	50.00
3 to 4 lbs	8	1910	1912						1					1	12.50	14.50	1	12.50
4 to 5 lbs	8	1910	1912						1	2				3	37.50	11.88	0	0.00
5 to 6 lbs	9	1910	1912							1			1	2	22.22	14.67	0	0.00
6 to 7 lbs	2	1910	1912											0	0.00	15.00	0	0.00
7 to 8 lbs	0													0				

Comparison of Results to Date-Pounds of Creosote per Cubic Foot of Timber Avr.

Amount Creosote per cubic foot	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
HEWN LONGLEAF PINE - Table 13																		
Less than 1 lb.	0													0				
1 to 2 lbs	7	1910	1912	2						1			1	4	57.14	14.57	0	0.00
2 to 3 lbs	7	1910	1912				1						1	2	28.57	14.14	0	0.00
3 to 4 lbs	6	1910	1912									1		1	16.67	14.83	0	0.00
4 to 5 lbs	1	1910	1912											0	0.00	15.00	0	0.00
5 to 6 lbs	0													0				
6 to 7 lbs	1	1910	1912											0	0.00	15.00	0	0.00
7 to 8 lbs	0													0				
	22			2			1			1		1	2	7	31.82	13.45	0	0.00
HEWN HEART PINE - Table 14																		
Less than 1 lb.	1	1910	1912											0	0.00	15.00	0	0.00
	2	1910	1913											0	0.00	14.00	0	0.00
1 to 2 lbs	49	1910	1912	1		1				1			1	4	8.16	14.55	0	0.00
	61	1910	1913				1			1			2	4	6.72	13.85	4	6.72
2 to 3 lbs	49	1910	1912	4						2				6	12.24	13.89	0	0.00
	43	1910	1913									1		1	2.33	13.98	1	2.33
3 to 4 lbs	22	1910	1912											0	0.00	15.00	0	0.00
	10	1910	1913											0	0.00	14.00	0	0.00
4 to 5 lbs	1	1910	1912											0	0.00	15.00	0	0.00
5 to 6 lbs	0													0				
6 to 7 lbs	0													0				
7 to 8 lbs	0													0				
	238			5		1	1			4		1	3	15	6.30	14.15	5	2.10
HEWN OAK - Table 15																		
Less than 1 lb.	34	1910	1912	3			3		3	4		2		15	44.12	12.64	1	2.94
1 to 2 lbs	16	1910	1912							1				1	6.25	14.81	0	0.00
2 to 3 lbs	0													0				
3 to 4 lbs	0													0				
4 to 5 lbs	0													0				
5 to 6 lbs	0													0				
6 to 7 lbs	0													0				
7 to 8 lbs	0													0				
	50			3			3		3	5		2		16	32.00	13.34	1	2.00

MIXTURE TREATED TIES-CLEVELAND, TEXAS
(Creosote-Petroleum)

Comparison of Results to Date-Pounds of Creosote per Cubic Foot of Timber

Amount Creosote per cubic foot	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
								HEWN GUM - Table 16										
Less than 1 lb.	10	1910	1912	2		1						1		4	40.00	11.80	0	0.00
	4	1910	1913											0	0.00	14.00	0	0.00
1 to 2 lbs.	44	1910	1912			1						2	1	4	9.09	14.79	0	0.00
	59	1910	1913							1				1	1.69	13.95	0	0.00
2 to 3 lbs.	23	1910	1912											0	0.00	15.00	0	0.00
	34	1910	1913											0	0.00	14.00	0	0.00
3 to 4 lbs.	3	1910	1912											0	0.00	15.00	0	0.00
	19	1910	1913							1				1	5.26	13.84	0	0.00
4 to 5 lbs.	0													0				
5 to 6 lbs.	0													0				
6 to 7 lbs.	0													0				
7 to 8 lbs.	0													0				
	196			2		2				2		3	1	10	5.10	14.17	0	0.00
								ALL WOODS - Table 17										
Less than 1 lb.	53	1910	1912	5		1	3		4	4		5	2	24	45.28	12.78	1	1.89
	7	1910	1913											0	0.00	14.00	0	0.00
1 to 2 lbs.	149	1910	1912	3		2				6		5	5	21	14.09	14.15	3	2.01
	179	1910	1913			1	2		2	14			6	25	13.97	13.69	6	3.35
2 to 3 lbs.	125	1910	1912	5	2		2		1	9			4	23	18.40	14.05	2	1.60
	122	1910	1913							5	2	3	2	12	9.84	13.81	3	9.84
3 to 4 lbs.	46	1910	1912	1					3	2		1		7	15.22	15.65	1	2.17
	40	1910	1913				2			2	1		1	6	15.00	13.50	0	0.00
4 to 5 lbs.	41	1910	1912	2					4	12			2	20	48.78	13.15	3	7.32
		1910	1913														0	0.00
5 to 6 lbs.	33	1910	1912						2	4		3	1	10	30.30	14.58	0	0.00
		1910	1913														0	0.00
6 to 7 lbs.	16	1910	1912						1	3			1	5	31.25	14.19	0	0.00
		1910	1913									0		0			0	0.00
7 to 8 lbs.	4	1910	1912									1		1	25.00	14.75	0	0.00
	467	1910	1912	16	2	3	5		15	40		15	15	111	23.77	14.03	10	2.14
	348	1910	1913			1	4		2	21	3	3	9	43	12.36	13.68	9	2.59
	815			16	2	4	9		17	61	3	18	24	154	18.90	13.88	19	2.33

(Creosote-Petroleum

COMPARISON OF RESULTS TO DATE - CREOSOTE-PETROLEUM MIXTURES

Symbol	Proportion of Mixture	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
									HEWN SAP PINE - Table 18										
3 BC	1 creo to 3 Beaumont	0													0				
2 BC	1 creo to 2 Beaumont	0													0				
RBM	1 creo to 2 Beaumont	29	1910	1913				2			6	1	1	4	14	48.28	12.86	0	0.00
RBM	1 creo to 4 Beaumont	28	1910	1912						1			5	3	9	32.14	14.54	4	14.29
		29	1910	1913							1			1	2	6.90	13.90	4	13.79
ROK	1 creo to 2 Oklahoma	18	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913								2	1	1	4	13.79	13.90	0	0.00
ROK	1 creo to 4 Oklahoma	29	1910	1913			1	1		2	11			1	16	55.17	12.52	0	0.00
OC	1 creo to 4 Oklahoma	40	1910	1912	1	2		1		1	11			4	20	50.00	13.23	0	0.00
2 EC	1 creo to 2 Ellinor	0													0				
		202			1	2	1	4		4	29	3	7	14	65	32.18	13.56	8	3.96
									HEWN LOBLOLLY PINE - Table 19										
3 BC	1 creo to 3 Beaumont	25	1909	1912	2					5	3		1	1	12	48.00	12.80	1	4.00
2 BC	1 creo to 2 Beaumont	15	1909-1910	1912							3		1	1	5	33.33	14.34	0	0.00
RBM	1 creo to 2 Beaumont	0	1910												0				
RBM	1 creo to 4 Beaumont	0	1910												0				
ROK	1 creo to 2 Oklahoma	0													0				
ROK	1 creo to 4 Oklahoma	0	1910												0				
OC	1 creo to 4 Oklahoma	24	1910	1912	1					2	11			1	15	62.50	12.79	2	8.33
2 EC	1 creo to 2 Ellinor	14	1909	1912						1			2		3	21.43	14.57	0	0.00
		78			3					8	17		4	3	35	44.87	13.42	3	3.85
									HEWN SHORTLEAF PINE - Table 20										
3 BC	1 creo to 3 Beaumont	12	1909	1912						2	1				3	25.00	14.08	2	16.67
2 BC	1 creo to 2 Beaumont	9	1909	1912										1	1	11.11	15.00	0	0.00
RBM	1 creo to 2 Beaumont	0													0				
RBM	1 creo to 4 Beaumont	0													0				
ROK	1 creo to 2 Oklahoma	0													0				
ROK	1 creo to 4 Oklahoma	0													0				
OC	1 creo to 4 Oklahoma	0													0				
2 EC	1 creo to 2 Ellinor	8	1910	1912							2				2	25.00	14.25	0	0.00
		29								2	3			1	6	26.90	14.41	2	6.90

MIXTURE TREATED TIES - CLEVELAND; TEXAS
(Creosote-Petroleum)

COMPARISON OF RESULTS TO DATE - CREOSOTE-PETROLEUM MIXTURES

Symbol	Proportion of Mixture	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
								HEWN LONGLEAF PINE - Table 21											
3 BC	1 creo to 3 Beaumont	10	1909	1912	2			1						1	4	40.00	12.00	0	0.00
2 BC	1 creo to 2 Beaumont	6	1909	1912											0	0.00	15.00	0	0.00
REM	1 creo to 2 Beaumont	0													0				
REM	1 creo to 4 Beaumont	0													0				
ROK	1 creo to 2 Oklahoma	0													0				
ROK	1 creo to 4 Oklahoma	0													0				
OC	1 creo to 4 Oklahoma	0													0				
2 EC	1 creo to 2 Ellinor	6	1909	1912							1		1	1	3	50.00	14.34	0	0.00
		22			2			1			1		1	2	7	31.82	13.45	0	0.00
								HEWN HEART PINE - Table 22											
3 BC	1 creo to 3 Beaumont	0													0				
2 BC	1 creo to 2 Beaumont	0													0				
REM	1 creo to 2 Beaumont	8	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913									1		1	3.45	13.98	1	3.45
REM	1 creo to 4 Beaumont	29	1910	1913							1			1	2	6.90	13.90	4	13.79
ROK	1 creo to 2 Oklahoma	10	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913											0	0.00	14.00	0	0.00
ROK	1 creo to 4 Oklahoma	19	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913					1					1	2	6.90	13.79	0	0.00
OC	1 creo to 4 Oklahoma	85	1910	1912	5		1				3			1	10	11.76	14.11	0	0.00
2 EC	1 creo to 2 Ellinor	0													0				
		238			5		1		1		4		1	3	15	6.30	14.15	5	2.10
								HEWN OAK - Table 23											
3 BC	1 creo to 3 Beaumont	0													0				
2 BC	1 creo to 2 Beaumont	0													0				
REM	1 creo to 2 Beaumont	0													0				
REM	1 creo to 4 Beaumont	0													0				
ROK	1 creo to 2 Oklahoma	0													0				
ROK	1 creo to 4 Oklahoma	10	1910	1912									1		1	10.00	14.90	0	0.00
OC	1 creo to 4 Oklahoma	40	1910	1912	3			3		3	5		1		15	37.50	11.70	1	2.50
2 EC	1 creo to 2 Ellinor	0													0				
		50			3			3		3	5		2		16	32.00	13.34	1	2.00

MIXTURE TREATED TIES - CLEVELAND TEXAS
(Creosote-Petroleum)
COMPARISON OF RESULTS TO DATE - CREOSOTE-PETROLEUM MIXTURES

Symbol	Proportion of Mixture	Number of Ties	Year Treated	Year Inserted	REMOVED 1915	1919	1920	1921	1922	1923	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Average Life in track to 10-20-27	Number in track showing slight decay	Percent in track showing slight decay
									HEWN GUM - Table 24										
3 BC	1 creo to 3 Beaumont	0													0				
2 BC	1 creo to 2 Beaumont	0													0				
R BM	1 creo to 2 Beaumont	8	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913							2				2	6.90	13.79	0	0.00
R BM	1 creo to 4 Beaumont	29	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913											0	0.00	14.00	0	0.00
R OK	1 creo to 2 Oklahoma	10	1910	1912											0	0.00	15.00	0	0.00
		29	1910	1913											0	0.00	14.00	0	0.00
R OK	1 creo to 4 Oklahoma	8	1910	1912									2		2	25.00	14.75	0	0.00
		29	1910	1913											0	0.00	14.00	0	0.00
OC	1 creo to 4 Oklahoma	25	1910	1912	2		2						1	1	6	24.00	13.44	0	0.00
2 EC	1 creo to 2 Ellinor	0													0				
		196			2		2				2		3	1	10	5.10	14.17	0	0.00
									ALL WOODS - Table 25										
3 BC	1 creo to 3 Beaumont	47	1910	1912	4			1		7	4		1	2	19	40.43	12.98	3	6.38
2 BC	1 creo to 2 Beaumont	38	1910	1912							3		1	2	6	15.79	14.74	0	0.00
RBM	1 creo to 2 Beaumont	8	1910	1912											0	0.00	15.00	0	0.00
		87	1910	1913				2			8	1	2	4	17	19.54	13.54	3	3.45
RBM	1 creo to 4 Beaumont	57	1910	1912						1			5	3	9	15.79	14.84	3	5.26
		87	1910	1913							2			2	4	4.60	13.93	6	6.90
ROK	1 creo to 2 Oklahoma	38	1910	1912											0	0.00	15.00	0	0.00
		87	1910	1913								2	1	1	4	4.60	13.94	0	0.00
ROK	1 creo to 4 Oklahoma	37	1910	1912									3		3	8.11	14.92	0	0.00
		87	1910	1913			1	2		2	11			2	18	20.69	13.31	0	0.00
OC	1 creo to 4 Oklahoma	214	1910	1912	12	2	3	4		6	30		2	7	66	30.84	13.50	4	1.87
2 EC	1 creo to 2 Ellinor	28	1910	1912						1	3		3	1	8	28.57	14.43	0	0.00
		467	1910	1912	16	2	3	5		15	40		15	15	111	23.77	14.03	10	2.14
		348	1910	1913			1	4		2	21	3	3	9	43	12.36	13.68	9	2.59
		815			16	2	4	9		17	61	3	18	24	154	18.90	13.88	19	2.33

Appendix F

(5-b) TREATMENT WITH A MIXTURE OF ZINC CHLORIDE AND PETROLEUM

R. S. Belcher, Chairman, Sub-Committee; J. E. Fanning, E. B. Fulks, W. R. Goodwin, L. J. Reiser, W. R. Rhodes, O. C. Steinmayer, G. C. Stephenson, T. H. Strate, J. H. Waterman.

Your Committee reported on this subject in 1924, 1925, and 1926*, and the report this year is a continuation of the subject.

Inspection of zinc-petroleum and straight zinc chloride ties in the Cleveland Test Section of the Santa Fe, which has been referred to in connection with the creosote-petroleum ties in the report on that subject, was made by the Committee in October, 1927, and the tables which follow are a study of the performance to date of these ties.

The ties were treated one to two years prior to date of insertion, and were air seasoned for several months following the zinc chloride treatment, after which the petroleum treatment was given. Some of the ties were not given the zinc-petroleum treatment, but were treated with zinc chloride only, and were inserted in the Test Section for comparison with those which received both the zinc chloride and petroleum.

Of the ties inserted in the year 1915 (Tables 1 to 23) 234 were of the zinc-petroleum treatment (Tables 1 to 8, and 13 to 20) and 119 were treated with zinc chloride only (Tables 9 to 11, and 21 to 23). Of the 234 zinc-petroleum ties, 21.37% had been removed up to the time of the October inspection, and the average life in track to date is 11.70 years. Of the 119 ties treated with zinc chloride only, 42.86% had been removed up to date of inspection, and the average life in track up to this date is 10.81 years, the zinc-petroleum ties having made a considerably better showing to date than the straight zinc chloride ties.

Of the 200 ties inserted in 1917, 100 were zinc-petroleum (Tables 24 to 28, and 34 to 38) and 100 were straight zinc chloride (Tables 29 to 33, and 39 to 43). During the ten years these ties have been in service, 12% of the zinc-petroleum ties have been removed and the average life in track up to date of inspection is 9.81 years; while 37% of the straight zinc chloride have been removed and the average life to date is 9.32 years, which comparison lines up very well with the ties inserted in 1915.

Other comparisons attempted by these tables do not show consistent results in the different groups, which may be due to the following: first—the number of ties in some of the groups is small; second—mechanical wear in its various forms is responsible to a very considerable extent for the failure of ties which have been removed to date; third—sufficient percentage of the ties have not been renewed to show definite results.

Recommendations

This report is submitted to the Association as information, with recommendation that the study of the subject be continued.

*Vol. 25, pages 895 to 897; Vol. 26, pages 109 to 111; Vol. 27, page 1001.

COMPARISON OF RESULTS TO DATE - AMOUNT OF ZINC CHLORIDE PER CUBIC FOOT

ZINC-PETROLEUM TREATMENT

(Both steamed and not steamed included)

Amount of zinc chloride per cubic foot	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
HEWN PINE TIES - Table 1											
Up to 1/4 lbs.	0								0	0	0
1/4 to 1/2	17	1913-14	1915		3		5		8	47.06	11.18
1/2 to 3/4	14	1913-14	1915				6		6	42.86	11.57
3/4 & over	1	1913-14	1915					1	1	100.00	12.00
	32	1913-14	1915		3		11	1	15	46.88	11.38
SAWN PINE TIES - Table 2											
Up to 1/4 lbs.	22	1913-14	1915		1		4		5	22.73	11.69
1/4 to 1/2	50	1913-14	1915		6		6		12	24.00	11.52
1/2 to 3/4	23	1913-14	1915				11		11	47.83	11.52
3/4 & over	3	1913-14	1915				2	1	3	100.00	11.33
	98	1913-14	1915		7		23	1	31	31.63	11.55
HEWN OAK TIES - Table 3											
Up to 1/4 lbs.	2	1913-14	1915						0	0.00	12.00
1/4 to 1/2	23	1913-14	1915						0	0.00	12.00
1/2 to 3/4	3	1913-14	1915						0	0.00	12.00
3/4 & over	0	1913-14	1915						0	0.00	0
	28	1913-14	1915						0	0.00	12.00
SAWN OAK TIES - Table 4											
Up to 1/4 lbs.	0								0	0.00	0
1/4 to 1/2	7	1913-14	1915				1		1	14.29	11.86
1/2 to 3/4	4	1913-14	1915						0	0.00	12.00
3/4 & over	0	1913-14							0	0.00	0
	11	1913-14	1915				1		1	9.09	11.91
HEWN GUM TIES - Table 5											
Up to 1/4 lbs.	0								0	0.00	0
1/4 to 1/2	2	1913-14	1915		1				1	50.00	10.50
1/2 to 3/4	3	1913-14	1915				1		1	33.33	11.67
3/4 & over	0								0	0.00	0.00
	5	1913-14	1915		1		1		2	40.00	11.20
SAWN GUM TIES - Table 6											
Up to 1/4 lbs.	9	1913-14	1915						0	0.00	12.00
1/4 to 1/2	17	1913-14	1915						0	0.00	12.00
1/2 to 3/4	17	1913-14	1915						0	0.00	12.00
3/4 & over	7	1913-14	1915						0	0.00	12.00
	50	1913-14	1915						0	0.00	12.00

COMPARISON OF RESULTS TO DATE - AMOUNT OF ZINC CHLORIDE PER CUBIC FOOT

ZINC-PETROLEUM TREATMENT

(Both steamed and not steamed included)

Amount of zinc chloride per cubic foot	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
HEWN ELM TIES - Table 7											
Up to 1/4 lbs.	1	1913-14	1915						0	0.00	12.00
1/4 to 1/2	1	1913-14	1915						0	0.00	12.00
1/2 to 3/4	5	1913-14	1915						0	0.00	12.00
3/4 & over	3	1913-14	1915				1		1	33.33	11.67
	10	1913-14	1915				1		1	10.00	11.90
ALL WOODS - Table 8											
Up to 1/4 lbs.	34	1913-14	1915		1		4		5	14.71	11.79
1/4 to 1/2	117	1913-14	1915		10		12		22	18.80	11.64
1/2 to 3/4	69	1913-14	1915				17	1	18	26.09	11.75
3/4 & over	14	1913-14	1915				3	2	5	35.71	11.79
	234	1913-14	1915		11		36	3	50	21.37	11.71

COMPARISON OF RESULTS TO DATE - AMOUNT OF ZINC CHLORIDE PER CUBIC FOOT

STRAIGHT ZINC CHLORIDE TREATMENT

(Both steamed and not steamed included)

Amount of zinc chloride per cubic foot	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
SAWN PINE TIES - Table 9											
Up to 1/4 lbs.	7	1913-14	1915		1				1	14.29	11.57
1/4 to 1/2	55	1913-14	1915	1	17	6	5		29	52.73	10.65
1/2 to 3/4	26	1913-14	1915		15	2	2		19	73.08	10.04
3/4 & over	5	1913-14	1915	2	3				5	100.00	7.80
	93	1913-14	1915	3	36	8	7		54	58.06	10.40
SAWN GUM TIES - Table 10											
Up to 1/4 lbs.	4	1913-14	1915						0	0	12.00
1/4 to 1/2	8	1913-14	1915						0	0	12.00
1/2 to 3/4	12	1913-14	1915				2		2	16.67	11.67
3/4 & over	2	1913-14	1915						0	0	12.00
	26	1913-14	1915				2		2	7.69	11.92
ALL WOODS - Table 11											
Up to 1/4 lbs.	11	1913-14	1915		1				1	9.09	11.73
1/4 to 1/2 lbs.	63	1913-14	1915	1	17	6	5		29	46.03	10.68
1/2 to 3/4	38	1913-14	1915		15	2	4		21	55.26	10.61
3/4 & over	7	1913-14	1915	2	3				5	71.43	9.00
	[illegible]	1913-14	1915	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	10.73

COMPARISON OF RESULTS TO DATE - AMOUNT OF ZINC CHLORIDE PER CUBIC FOOT

BOTH ZINC PETROLEUM TREATMENT AND STRAIGHT ZINC CHLORIDE

ALL WOODS

(Both steamed and not steamed included)

Table 12

	Number Treated	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
0 to 1/4 lbs.	45	1913-14	1915		2		4		6	13.33	11.78
1/4 to 1/2	180	1913-14	1915	1	27	6	17		51	28.33	11.36
1/2 to 3/4	107	1913-14	1915		15	2	21	1	39	36.45	11.35
3/4 lb. & over	21	1913-14	1915	2	3		3	2	10	47.62	10.86
All amounts	353	1913-14	1915	3	47	8	45	3	106	30.03	11.38

COMPARISON OF RESULTS TO DATE - STEAMED AND NOT STEAMED

ZINC PETROLEUM TREATMENT

(All amounts zinc chloride per cubic foot)

	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
					HEWN PINE TIES - Table 13						
No steam	32	1913-14	1915		3		11	1	15	46.88	11.38
20 lbs - 3 hours	0								0	0	0
30 lbs - 2 hours	0								0	0	0
30 lbs - 3 hours	0								0	0	0
	32	1913-14	1915		3		11	1	15	46.88	11.38
					SAWN PINE TIES - Table 14						
No steam	30	1913-14	1915				4		4	13.33	11.87
20 lbs - 3 hours	19	1913-14	1915				10	1	11	57.89	11.47
30 lbs - 2 hours	49	1913-14	1915		7		9		16	32.65	11.39
30 lbs - 3 hours	0								0	0	0
	98	1913-14	1915		7		23	1	31	31.63	11.55
					HEWN OAK TIES - Table 15						
No steam	28	1913-14	1915						0	0	12.00
20 lbs - 3 hours	0								0	0	0
30 lbs - 2 hours	0								0	0	0
30 lbs - 3 hours	0								0	0	0
	28	1913-14	1915						0	0	12.00
					SAWN OAK TIES - Table 16						
No steam	10	1913-14	1915				1		1	10.00	11.90
20 lbs - 3 hours	1	1913-14	1915						0	0	12.00
30 lbs - 2 hours	0								0	0	0
30 lbs - 3 hours	0								0	0	0
	11	1913-14	1915				1		1	9.09	11.91
					HEWN GUM TIES - Table 17						
No steam	5	1913-14	1915		1			1	2	00000	11.40
20 lbs - 3 hours	0								0	0	0
30 lbs - 2 hours	0								0	0	0
30 lbs - 3 hours	0								0	0	0
	5	1913-14	1915		1			1	2	40.00	11.20
					SAWN GUM TIES -Table 18						
No steam	41	1913-14	1915						0	0	12.00
20 lbs - 3 hours	3	1913-14	1915						0	0	12.00
30 lbs - 2 hours	0								0	0	.00
30 lbs - 3 hours	6	1913-14	1915						0	0	12.00
	50	1913-14	1915						0	0	12.00

COMPARISON OF RESULTS TO DATE - STEAMED AND NOT STEAMED

ZINC PETROLEUM TREATMENT

(All amounts zinc chloride per cubic foot)

	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
HEWN ELM TIES - Table 19											
No steam	10	1913-14	1915				1		1	10.00	11.90
20 lbs - 3 hours	0						0		0	0.00	0
30 lbs - 2 hours	0						0		0	0.00	0
30 lbs - 3 hours	0						0		0	0.00	0
	10	1913-14	1915				1		1	10.00	11.90
ALL WOODS - Table 20											
No steam	156	1913-14	1915		4		17	2	23	14.74	11.81
20 lbs - 3 hours	23	1913-14	1915				10	1	11	47.83	11.52
30 lbs - 2 hours	49	1913-14	1915		7		9		16	32.65	11.39
30 lbs - 3 hours	6	1913-14	1915						0	0.00	12.00
	234	1913-14	1915		11		36	3	50	21.37	11.71

COMPARISON OF RESULTS TO DATE - STEAMED AND NOT STEAMED

STRAIGHT ZINC CHLORIDE TREATMENT

(All amounts zinc chloride per cubic foot)

	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
SAWN PINE TIES - Table 21											
No steam	10	1913-14	1915	1	6		1		8	80.00	8.90
20 lbs - 3 hours	10	1913-14	1915		2		3		5	50.00	11.10
30 lbs - 2 hours	73	1913-14	1915	2	28	8	3		41	56.16	10.92
30 lbs - 3 hours	0								0	0.00	0
	93	1913-14	1915	3	36	8	7		54	58.06	10.40
SAWN GUM TIES - Table 22											
No steam	9	1913-14	1915				1		1	11.11	11.89
20 lbs - 3 hours	0									0.00	0
30 lbs - 2 hours	17	1913-14	1915				1		1	5.88	11.94
30 lbs - 3 hours	0									0.00	0
	26	1913-14	1915				2		2	7.69	11.92
ALL WOODS - Table 23											
No steam	19	1913-14	1915	1	6		2		9	47.37	10.63
20 lbs - 3 hours	10	1913-14	1915		2		3		5	50.00	11.10
30 lbs - 2 hours	90	1913-14	1915	2	28	8	4		42	46.67	10.71
30 lbs - 3 hours	0								0	0.00	0
	119	1913-14	1915	3	36	8	9		56	47.06	10.73

COMPARISON OF RESULTS TO DATE - AMOUNT OF ZINC CHLORIDE PER CUBIC FOOT

ZINC PETROLEUM TREATMENT

(Both steamed and not steamed included)

Amount of zinc chloride per cubic foot	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
					HEWN PINE TIES - Table 24						
Up to 1/4 lbs.	0								0	0.00	0
1/4 to 1/2	1	1915	1917			1			1	100.00	8.00
1/2 to 3/4	5	1915	1917			1			1	20.00	9.60
3/4 & over	14	1915	1917					2	2	14.29	10.00
	20	1915	1917			2		2	4	20.00	9.80
					SAWN PINE TIES - Table 25						
Up to 1/4 lbs.	0								0	0.00	0
1/4 to 1/2	22	1915	1917						0	0.00	10.00
1/2 to 3/4	14	1915	1917						0	0.00	10.00
3/4 & over	4	1915	1917						0	0.00	10.00
	40	1915	1917						0	0.00	10.00
					HEWN OAK TIES - Table 26						
Up to 1/4 lbs.	2	1915	1917			1			1	50.00	9.00
1/4 to 1/2	18	1915	1917		3			2	5	27.78	9.50
1/2 to 3/4	0								0	0.00	0
3/4 & over	0								0	0.00	0
	20	1915	1917		3	1		2	6	30.00	9.45
					HEWN GUM TIES - Table 27						
Up to 1/4 lbs.	1	1915	1917						0	0.00	10.00
1/4 to 1/2	4	1915	1917						0	0.00	10.00
1/2 to 3/4	3	1915	1917			1			1	33.33	9.33
3/4 & over	12	1915	1917			1			1	8.33	9.83
	20	1915	1917			2			2	10.00	9.80
					ALL WOODS - Table 28						
Up to 1/4 lbs.	3	1915	1917			1			1	33.33	9.33
1/4 to 1/2	45	1915	1917		3	1		2	6	13.33	9.76
1/2 to 3/4	22	1915	1917			2			2	9.09	9.82
3/4 & over	30	1915	1917			1		2	3	10.00	9.60
	100	1915	1917		3	5		4	12	12.00	9.81

COMPARISON OF RESULTS TO DATE - AMOUNT OF ZINC CHLORIDE PER CUBIC FOOT

STRAIGHT ZINC CHLORIDE TREATMENT

(Both steamed and not steamed included)

Amount of zinc chloride per cubic foot	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
HEWN PINE TIES - Table 29											
Up to 1/4 lbs.	1	1915	1917			1			1	100.00	8.00
1/4 to 1/2	4	1915	1917			3			3	75.00	8.50
1/2 to 3/4	3	1915	1917			2			2	66.67	8.67
3/4 & over	12	1915	1917			9		3	12	100.00	8.50
	20	1915	1917			15		3	18	90.00	8.50
SAWN PINE TIES -Table 30											
Up to 1/4 lbs.	1	1915	1917			1			1	100.00	8.00
1/4 to 1/2	15	1915	1917			1			1	6.67	9.87
1/2 to 3/4	22	1915	1917			7			7	31.82	9.36
3/4 & over	2	1915	1917			1			1	50.00	9.00
	40	1915	1917			10			10	25.00	9.50
HEWN OAK TIES -Table 31											
Up to 1/4 lbs.	5	1915	1917			1			1	20.00	9.60
1/4 to 1/2	15	1915	1917			7			7	46.67	9.07
1/2 to 3/4	0								0	0.00	0
3/4 & over	0								0	0.00	0
	20	1915	1917			8			8	40.00	9.20
HEWN GUM TIES -Table 32											
Up to 1/4 lbs.	1	1915	1917			1			1	100.00	8.00
1/4 to 1/2	7	1915	1917						0	0.00	10.00
1/2 to 3/4	6	1915	1917						0	0.00	10.00
3/4 & over	6	1915	1917						0	0.00	10.00
	20	1915	1917			1			1	5.00	9.90
ALL WOODS - Table 33											
Up to 1/4 lbs.	8	1915	1917			4			4	50.00	9.00
1/4 to 1/2	41	1915	1917			11			11	26.83	9.46
1/2 to 3/4	31	1915	1917			9			9	29.03	9.42
3/4 & over	20	1915	1917			10		3	13	65.00	9.00
	100	1915	1917			34		3	37	37.00	9.32

COMPARISON OF RESULTS TO DATE - STEAMED AND NOT STEAMED

ZINC PETROLEUM TREATMENT

(All amounts zinc chloride per cubic foot)

	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
HEWN PINE TIES - Table 34											
No steam	5	1915	1917			1			1	20.00	9.60
20 lbs - 2 hours	5	1915	1917						0	0.00	10.00
20 lbs - 4 hours	5	1915	1917						0	0.00	10.00
20 lbs - 6 hours	5	1915	1917			1		2	3	60.00	9.60
	20	1915	1917			2		2	4	20.00	9.80
SAWN PINE TIES - Table 35											
No steam	10	1915	1917						0	0.00	10.00
20 lbs - 2 hours	10	1915	1917						0	0.00	10.00
20 lbs - 4 hours	10	1915	1917						0	0.00	10.00
20 lbs - 6 hours	10	1915	1917						0	0.00	10.00
	40	1915	1917						0	0.00	10.00
HEWN OAK TIES - Table 36											
No steam	5	1915	1917						0	0.00	10.00
20 lbs - 2 hours	5	1915	1917					2	2	40.00	10.00
20 lbs - 4 hours	5	1915	1917		3	1			4	80.00	7.80
20 lbs - 6 hours	5	1915	1917						0	0.00	10.00
	20	1915	1917		3	1		2	6	30.00	9.45
HEWN GUM - Table 37											
No steam	5	1915	1917						0	0.00	10.00
20 lbs - 2 hours	5	1915	1917						0	0.00	10.00
20 lbs - 4 hours	5	1915	1917			2			2	40.00	9.20
20 lbs - 6 hours	5	1915	1917						0	0.00	10.00
	20	1915	1917			2			2	10.00	9.80
ALL WOODS - Table 38											
No steam	25	1915	1917			1			1	4.00	9.92
20 lbs - 2 hours	25	1915	1917					2	2	8.00	10.00
20 lbs - 4 hours	25	1915	1917		3	3			6	24.00	9.40
20 lbs - 6 hours	25	1915	1917			1		2	3	12.00	9.96
	100	1915	1917		3	5		4	12	12.00	9.81

COMPARISON OF RESULTS TO DATE - STEAMED AND NOT STEAMED

STRAIGHT ZINC CHLORIDE TREATMENT

(All amounts zinc chloride per cubic foot)

	Number Inserted	Year Treated	Year Inserted	1921	1924	1925	1926	1927	Number Removed to 10-20-27	Percent Removed to 10-20-27	Life in track to 10-20-27
					HEWN PINE TIES - Table 39						
No steam	5	1915	1917			4			4	80.00	8.40
20 lbs - 2 hours	5	1915	1917			2		2	4	80.00	9.20
20 lbs - 4 hours	5	1915	1917			4		1	5	100.00	8.40
20 lbs - 6 hours	5	1915	1917			5			5	100.00	8.00
	20	1915	1917			15		3	18	90.00	8.50
					SAWN PINE TIES - Table 40						
No steam	10	1915	1917			2			2	20.00	9.60
20 lbs - 2 hours	10	1915	1917			3			3	30.00	9.40
20 lbs - 4 hours	10	1915	1917			3			3	30.00	9.40
20 lbs - 6 hours	10	1915	1917			2			2	20.00	9.60
	40	1915	1917			10			10	25.00	9.50
					HEWN OAK TIES - Table 41						
No steam	5	1915	1917			1			1	20.00	9.60
20 lbs - 2 hours	5	1915	1917			2			2	40.00	9.20
20 lbs - 4 hours	5	1915	1917			3			3	60.00	8.80
20 lbs - 6 hours	5	1915	1917			2			2	40.00	9.20
	20	1915	1917			8			8	40.00	9.20
					HEWN GUM TIES - Table 42						
No steam	5	1915	1917						0	0.00	10.00
20 lbs - 2 hours	5	1915	1917			1			1	20.00	9.60
20 lbs - 4 hours	5	1915	1917						0	0.00	10.00
20 lbs - 6 hours	5	1915	1917						0	0.00	10.00
	20	1915	1917			1			1	5.00	9.90
					ALL WOODS - Table 43						
No steam	25	1915	1917			7			7	28.00	9.44
20 lbs - 2 hours	25	1915	1917			8		2	10	40.00	9.36
20 lbs - 4 hours	25	1915	1917			10		1	11	44.00	9.20
20 lbs - 6 hours	25	1915	1917			9			9	36.00	9.28
	100	1915	1917			34		3	37	37.00	9.32

Appendix G

(5-c) THE EFFECT OF PRESERVATIVE TREATMENT WITH AIR-SEASONED DOUGLAS FIR

R. S. Belcher, Chairman, Sub-Committee; Andrew Gibson, R. S. Hubley, W. H. Kirkbride, F. D. Mattos, G. P. MacLaren, W. D. Pender, L. J. Reiser, Dr. Hermann von Schrenk, W. L. Smith, G. C. Stephenson, C. M. Taylor, J. H. Waterman.

This Committee reports that it does not seem to be advisable to attempt to write specifications for Air-Seasoned Douglas Fir for this year's report because of the fact that there is a very small amount of information additional to that when "Specifications for the Preservative Treatment for Douglas Fir" were submitted to the Association for adoption and publication in the Manual at the last convention and feels that it should attempt to obtain history of Douglas Fir in structures, ties and tracks before preparing specifications.

For this a questionnaire has been issued so as to gather as much available information as possible in dealing with past experience, before proceeding on attempt to prepare specifications.

REPORT OF COMMITTEE XI—RECORDS AND ACCOUNTS

J. H. Hande, *Chairman;*
E. Y. Allen,
B. A. Bertenshaw,
A. M. Blanchard,
R. R. L. Bullard,
E. S. Butler,
E. B. Crane,
J. W. Dansey,
C. C. Haire,
H. E. Hale,
W. A. Hill,
G. R. Walsh, *Vice-Chairman;*
Alfred Holmead,
C. A. Knowles,
Henry Lehn,
H. T. Livingston,
E. W. Metcalf,
C. K. Smith,
James Stephenson,
V. R. Walling,
H. R. Westcott,
Louis Wolf,
Committee.

To the American Railway Engineering Association:

Your Committee on Records and Accounts respectfully presents herewith its annual report to the Association covering the subjects assigned, as follows:

(1) Revision of the Manual.

The changes made by this Committee in the revised Manual and its plans for future revisions are reported upon in Appendix A.

(2) Continue study of methods for reporting proportional increases in expenditures resulting from increased use of physical property and also through increase of property investment, collaborating with Committee XXI—Economics of Railway Operation.

A report on the results of collaboration of this Committee with Committee XXI is covered in Appendix B.

(3) Develop units or methods for use in control of maintenance expenditures from data taken from maintenance foremen's reports and used in preparing reports for the I. C. C., collaborating with Committee XXII—Economics of Railway Labor and Committee XXI—Economics of Railway Operation.

The report on this assignment is covered in Appendix C.

(4) Report on the use made of aerial surveys and results obtained therefrom.

The report on this assignment is presented in Appendix D.

(5) Collaborate with other Committees in the preparation and design of forms pertinent to their work.

The plan of Committee XI for providing the forms for the Construction, Maintenance and Valuation Departments of the railroads, and for other Committees of this organization, is presented in Appendix E.

(6) Report progress upon changes or revisions in I. C. C. Classification of Accounts.

A resumé of the work done by various agencies interested in revision of the classification is presented in Appendix F.

(7) Plans, methods and forms for gathering and recording data for keeping up to date the physical and valuation records of the property of railways.

The report on this assignment for inclusion in the Manual is presented in Appendix G.

(8) Methods and forms for handling the Interstate Commerce Commission's requirements under Order 15100—Depreciation Charges of Steam Railroad Companies.

The Committee has been instructed by the Board of Direction to discontinue study on this assignment pending the outcome of hearings on the Order scheduled for November 9, 1927.

(9) Outline of work for ensuing year.

See "Recommendations for Future Work" below.

Action Recommended

Your Committee's recommendations are as follows:

1. That the conclusions in Appendices B, C and D be accepted as final and that the subjects be discontinued.

2. That the progress reports made in Appendices E and F be accepted as information.

3. That the report made in Appendix G be accepted for publication in the Manual.

Recommendations for Future Work

The following subjects are recommended for future work:

1. Revision of Manual.

2. Collaborate with other Committees in the preparation and design of forms pertinent to their work.

3. Report progress upon changes or revisions in I. C. C. Classification of Accounts.

4. Develop such revisions in methods and forms for gathering and recording data for keeping up to date the physical and valuation records of the property of railways as are made necessary by changes in governmental regulations.

5. Methods and forms for handling the Interstate Commerce Commission's requirements under Order 15100—Depreciation Charges of Steam Railroad Companies.

6. Study of maintenance foremen's reports with the accounting and statistical report procedure in the Maintenance Department developed therefrom.

IN MEMORIAM

Committee XI records its deep sense of loss at the death on May 31, 1927, of William H. Burrage, a member of this Committee for several years. His wealth of experience and sound judgment were invaluable in the deliberations of the Committee. His many admirable personal qualities make his loss as a friend particularly felt.

Respectfully submitted,

THE COMMITTEE ON RECORDS AND ACCOUNTS,

J. H. HANDE, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

C. K. Smith, Chairman, Sub-Committee; A. M. Blanchard, R. R. L. Bullard, E. S. Butler, C. C. Haire, H. E. Hale, W. A. Hill, Alfred Holmead, H. T. Livingston, V. R. Walling, Louis Wolf.

The Committee has completed the rearrangement of material for the revised Manual. That rearrangement has been in accordance with a comprehensive plan looking to a systematic building up of Committee XI's section of the Manual.

An exposition of this plan is given hereinafter in Appendix E.

Appendix B

(2) CONTINUE STUDY OF METHODS FOR REPORTING PROPORTIONAL INCREASES IN EXPENDITURES RESULTING FROM INCREASED USE OF PHYSICAL PROPERTY AND ALSO THROUGH INCREASE OF PROPERTY INVESTMENT, COLLABORATING WITH COMMITTEE XXI—ECONOMICS OF RAILWAY OPERATION

H. E. Hale, Chairman, Sub-Committee; E. Y. Allen, E. S. Butler, C. A. Knowles, Henry Lehn, E. W. Metcalf, V. R. Walling, H. R. Westcott, Louis Wolf.

Committee XI has reviewed the report of Committee XXI—Economics of Railway Operation, printed on pages 911 to 926, inclusive, of the 1925 Proceedings (Volume 26) and adopted by the Association in March, 1925, for inclusion in the Manual (page 1351, Volume 26). In this report detailed instructions are given for compiling the data under the two methods proposed.

Committee XI has collaborated with Committee XXI—Economics of Railway Operation and that Committee is in accord with the views of Committee XI that no special printed and ruled forms need be designed and recommended by Committee XI at this time, and that plain, unruled paper work sheets only are necessary in applying either method recommended.

It is recommended that this subject be dropped.

Appendix C

(3) DEVELOP UNITS OR METHODS FOR USE IN CONTROL OF MAINTENANCE EXPENDITURES FROM DATA TAKEN FROM MAINTENANCE FOREMEN'S REPORTS AND USED IN PREPARING REPORTS FOR THE I.C.C., COLLABORATING WITH COMMITTEE XXII—ECONOMICS OF RAILWAY LABOR, AND COMMITTEE XXI —ECONOMICS OF RAILWAY OPERATION

B. A. Bertenshaw, Chairman, Sub-Committee; E. B. Crane, Henry Lehn, H. T. Livingston, C. K. Smith, James Stephenson, G. R. Walsh, H. R. Westcott.

Committee XI is of the opinion that the scope of its assignment is limited to the design of any form required in connection with the reports of Committee XXI—Economics of Railway Operation, and Committee XXII—Economics of Railway Labor.

Committee XI has collaborated and agrees with Committees XXI and XXII that the reports of their Committees require no specially designed forms, and respectfully recommends that it be relieved from further study of this subject.

Appendix D

(4) REPORT ON THE USE MADE OF AERIAL SURVEYS AND RESULTS OBTAINED THEREFROM

G. R. Walsh, Chairman, Sub-Committee; B. A. Bertenshaw, A. M. Blanchard, E. B. Crane, J. W. Dansey, W. A. Hill, C. A. Knowles, E. W. Metcalf, James Stephenson.

Indicative of the widespread interest that is being taken in Aerial Surveying a surprisingly large amount of literature, both technical and popular, has appeared on this subject within the past few years. A bibliography has been prepared listing the more important books and articles on this subject and is submitted with this report.

Aerial photography is useful in supplementing the present ground methods of surveying. It has proved of direct practical value for engineering projects such as power transmission surveys, railroad location surveys, reservoir surveys, harbor surveys, large area maps, city maps, traffic studies, flood control, timber surveys, legal evidence, United States Geological surveys, War Department maps, Dominion Land surveys, tax assessments and city planning.

Aerial photographs are in general of two kinds, depending upon whether the photograph is taken with the camera pointing obliquely or vertically downward. The application of aerial photography to map making has been developed extensively by the United States and Canadian Governments. Private capital has also contributed a great deal toward development of

aerial mapping in a practical way and in the United States several commercial companies are exclusively aerial surveying concerns.

Two distinct types of maps have come into use for engineering purposes, each of which offers special advantages for certain purposes. The mosaic or photographic map is built up of contact prints to produce a continuous photostatic representation of the area being surveyed. When component photographs are rephotographed to bring them to uniform scale the map is very satisfactory for reconnaissance purposes if the area mapped is flat or only slightly rolling. A line map is produced by transferring to tracing cloth or paper the more important features portrayed in the aerial photograph. Four methods of doing this have been developed:

1. In the method used by the United States Geographic Survey the photographs are rectified and the details desired are taken off on sheets which are sent to the field to have the contours, boundary lines, etc., added by the topographer. The final map is then made from those sheets.

2. In the Tennessee River method the contours are sketched on the original photographs in the field. The desired details are then transferred to the final map by hand methods.

3. In the Canadian method oblique photographs are used and by a system of perspective grid lines the features are drawn off to scale on the map.

4. In the fourth method the successive photographs are taken so that each point on the ground appears in three pictures. The photographs are rectified and by use of the stereoscopic principle, the elevation of desired points is located and the contour lines drawn on the photographs. The map is then drawn from the corrected and contoured photograph.

In surveys combining photography and ground work, the aerial work is usually done by companies specializing in that field and the ground work by the companies purchasing the photographic service. Aerial photographic service is usually done under contract to deliver certain material for a specified sum. The price depends upon the material delivered, the amount of flying involved and on flying conditions.

Conclusions

The Committee is of the opinion that owing to the commercial nature of aerial surveying and the contractual relations existing between the purchaser and the company specializing in aerial photography, no recommended practice should be submitted as the result of this Committee's study of the subject.

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Appendix E

(5) COLLABORATE WITH OTHER COMMITTEES IN THE PREPARATION AND DESIGN OF FORMS PERTINENT TO THEIR WORK

C. K. Smith, Chairman, Sub-Committee; A. M. Blanchard, R. R. L. Bullard, E. S. Butler, C. C. Haire, H. E. Hale, W. A. Hill, A. Holmead, H. T. Livingston, V. R. Walling, Louis Wolf.

In addition to the definite instruction to Committee XI embodied in assignments (2) and (3) to collaborate with Committees XXI and XXII on specific phases of those assignments that have points of contact with the work of the committees named, our Committee has been given this general assignment to "Collaborate with other Committees in the preparation and design of forms pertinent to their work."

The specific collaborations having been accomplished, for our Committee to wait, under this general assignment, until forms are presented to it for consideration by other committees, makes this general assignment passive in character. We have chosen therefore to give active consideration to the scope and field of activity of this Committee, with a view to determining our points of contact with the work of other committees.

We have approached the question from this point of view: that the output of this and other committees is intended for information of or active use by some one or several sections of a railroad's engineering organization. The forms or records designed or recommended by this Committee are for specific use by some such railway engineering organization unit.

To determine how adequately the forms and records recommended by this Committee are supplying the needs of the railway engineering organization units, we have endeavored to list, as completely as possible, all of the positions (functions), or units in a typical railway engineering organization and to check off the forms now available for each such position or function. From this we should be able to tell what forms or records are needed that have as yet not been supplied. The design of such needed forms or records in collaboration with other committees should then be the future objective of Committee XI.

In endeavoring to set up a typical organization outline, we face the difficulty of making it representative of any one of several types of organization. We have chosen to consider the entire matter from the viewpoint of "functions" rather than from that of relative positions. It appears to

us that the entire field of railway engineering could be divided, for our purpose, into three major functions or departments:

(A) Design and Construction.
(B) Maintenance.
(C) Valuation.

These functions exist whatever the type of organization and specific duties in each field are performed by certain individuals or positions no matter what such positions may be named in this or that plan of organization.

We have set up in each of the three major departments a list of positions, the names of which will indicate the scope of the activities of that position. In this preliminary report we have listed for each position only the forms already designed and recommended. We invite suggestions as to additional forms that may be considered necessary for any one of these position, or that may be suggested by the activities of other committees.

Since forms originate in the lower positions and are referred to the higher positions, we have listed the positions in the reverse order of their responsibilities, *i. e.,* foreman first and chiefs last. Reference has been given to form numbers and pages where these forms appear in the 1921 Manual, and to Bulletins where their presentation may be noted.

This list indicates the manner in which Committee XI has recommended that its material for the new Manual be arranged. It was so made with the idea of facilitating the finding of a desired form as well as to furnish a check list that would serve to call to attention forms not yet designed.

This list, concerning which we invite suggestions, is as follows:

(A) DESIGN AND CONSTRUCTION DEPARTMENT

		1921 Manual Reference		*Bulletin Reference*	
Position Originating Form	*Title of Form*	Form No.	Page No.	Bull. No.	Page No.
Foreman	Time Roll	1119	525		
Construction Inspector	Pile Record Form	701	287		
Materials Inspector	Report of Chemical and Physical Examination of Rails	401-A Rev.		295	926
	Certificate of Inspection	401-B Rev.		295	927
	Report of Shipment	401-C		295	929
Resident Engineer	Daily Track Laying Report and Record	1100	501		
	Daily Ballasting Report and Record	1101	502		
	Resident Engineer's Monthly Estimate of Grading	1102	503		

Position Originating Form	Title of Form	1921 Manual Reference Form No.	1921 Manual Reference Page No.	Bulletin Reference Bull. No.	Bulletin Reference Page No.
	Resident Engineer's Monthly Estimate of Bridges and other Roadway items	1103	504		
	Resident Engineer's Monthly Estimate of Buildings	1104	505		
	Progress Profile	1122	540		
	Steam Shovel Reports. (See page 49 for description.)				
Electrical Engineer	Electrical Wiring Symbols			249	35
	Form of Agreement for Purchase of Electrical Energy			289	49
Signal Engineer	Conventional Signs for Signals and Interlocking		554		
Assistant Engineer or Engineer of Construction	Assistant Engineer's Consolidated Monthly Estimate	1105	506		
Any officer in charge of work	Authority for Expenditure	1113	513		
	Detailed Estimate	1114 Rev.		249	32
Chief Engineer	Form of Proposal		954		
	Form of Construction Contract			293	439
	Form of Bond		967		
	Conventional Signs, Maps and Profiles		541		
	Conventional Signs, Architectural Details			257	33
	Specifications for Maps and Profiles		530		
	Form of Option for Purchase of Land			278	65
(B)	MAINTENANCE DEPARTMENT				
All Foremen	Time Roll	1119	525		
Track Foreman	Report of Rail Failure in Main Track	402-A	146		
	Monthly Track Material Report	1107	508		
	Report of Work Order Work			250	77

Position Originatin Form	Title of Form	1921 Manual Reference Form No.	Page No.	Bulletin Reference Bull. No.	Page No.
	Daily Record Track Work Performance.			250	56-G
	Motor Car Operator's and Maintainer's Monthly Report			289	48-2
Bridge Foreman	Monthly Bridge Material Report	1108	509		
	Bridge Section Tool Report	1109	509		
Painter Foreman	Building Painting Report	600		287	66
Steam Shovel and Ditcher Foreman	Steam Shovel Reports (See page 49 for description)				
Pumper	Pumper's Daily Report	1301	677		
Division Bridge Inspector	Current Bridge Inspection Report	1111	512		
Motor Car Inspector	Motor Car Condition Report			289	47
General Bridge Inspector	Bridge Inspection Report	1110	510		
Signal Maintainer	Signal Maintainer's Report (see Form R.S.A.-21)				
	Signal Inspector's or Maintainer's Report (See Form R.S.A.-22)				
Signal Supervisor	Trainmen's Telegraphic Report (See Form R.S.A.-11)				
	Dispatcher's Telegraphic Report (See Form R.S.A.-12)				
	Signal Engineer's or Supervisor's Report (See Form R.S.A.-3)				
Division Engineer	Rail Failures for month on Division	402-B	149		
	Statement of Rails in Main Track—Division	402-D	151		
	Statement of Cost of Pumping Water	1302	678		
	Water Station Record	1303	679		
	Record of Deep Wells	1304	680		

Position Originat-in Form	Title of Form	1921 Manual Reference Form No.	1921 Manual Reference Page No.	Bulletin Reference Bull. No.	Bulletin Reference Page No.
Supervisor Wood Preserving Plant	Form A—Report of Inspection of Treatment	1700	851		
	Form B—Report of Inspection of Treatment	1701	852		
Supervisor Work Equipment and Roadway Machines	Recapitulation of Roadway Motor-Car Report			289	48
	Roadway Motor Car Service and Maintenance			289	48-4
Any officer in charge of work	Authority for Expenditure	1113	513		
	Detailed Estimate	1114 Rev.		249	32
Chief Engineer of Maintenance	Contract and Lease Record	1120	520		
	Track Chart	1121	539		
	Rail Failures for Year	402-C Rev.		295	930
	Statement of Transverse Fissure Rail Failures	402-E Rev.		295	932
	Manufacturing Record of Interior Fissure Rail Heats	402-F		257	20
	Location Diagram of Rails Removed	403-A	152		
	Diagram showing lines of wear	403-B	153		
	Statement of Comparative Wear of Test Rail	403-C	154		
	Side Track Record	1106	510-11		
	Register of Title Deeds (See D.V. Forms 107-8 I.C.C.)				
	Form of Agreement for Trackage Rights			267	58
	Form of License for wires, pipes, conduits, drains, hopper pits, and other structures on Railway property.			267	65
	Form of Agreement for placing snow or sand fences beyond the Railway Company's property Line			267	67

Position Originat-in Form	Title of Form	1921 Manual Reference Form No.	Page No.	Bulletin Reference Bull. No.	Page No.
	Form of Agreement for Joint Use of Passenger Station facilities			278	59
	Form of Agreement for joint use of poles on Railway Rights of Way			289	52
	Form of Agreement for furnishing water from Railway water systems to Employees and others			293	467
	(C) VALUATION DEPARTMENT				
Supervisor Valuation Order No. 3	Register of Authorities for Expenditures	1115	517		
	Roadway Completion Report	1117 to 1117-C	519		
	Equipment Completion Report	1118 Rev.		249	34
Supervisor R & E Accounting Branch	Monthly Report of Expenditures	1116	518		
Auditor of Capital Expenditures	Authority for Expenditure	1113 1114	513		
	Detailed Estimate	Rev.		249	32

Conclusion

It is the recommendation of this Committee that all of the forms used by the Engineering Departments of railways in their routine operations which are approved by this Association should be included in Committee XI's section of the Manual, suitably classified and arranged for ready reference.

Appendix F

(6) REPORT PROGRESS UPON CHANGES OR REVISIONS IN I.C.C. CLASSIFICATIONS OF ACCOUNTS

Investigated and Reported by Alfred Holmead.

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INTRODUCTORY STATEMENT

This report is submitted in response to the assignment to this Committee calling for a report upon the progress made in the matter of revising the Interstate Commerce Commission's accounting classifications. The information utilized in preparing the following statement has appeared either in printed bulletins issued by the Railway Accounting Officers' Association (which association has been in conference and co-operation with representatives of the Interstate Commerce Commission concerning the proposed revisions), in general notices issued by the Secretary of the Commission, in annual reports of the Commission, or in published articles. The statement is devoid of discussion or comment by this Committee, it being merely a resumé of the work which has been done and the revisions proposed by the agencies directly involved in the work of revising the several classifications.

Various drafts of proposed revised classifications have been circulated from time to time by the Bureau of Accounts of the Interstate Commerce Commission. The most recent drafts are those of April, 1927, printed in Bulletin 113 of the Railway Accounting Officers' Association.

The following statement is a review of the tentative revisions as far as they have progressed at the time this report is submitted (November 9, 1927). The proposed revisions have not been passed on by the Commission.

GENERAL STATEMENT

In its annual reports to Congress for 1921 and 1922 the Interstate Commerce Commission made reference to a contemplated revision of its accounting regulations, intended to make them responsive to requirements imposed by new legislation and to improve them in the light of the experience gained in their practical application during recent years. Regarding the latter purpose, the revision was to be undertaken with a view to relieving the carriers from the burden of recording unnecessary information and with a view to securing all useful information in the form that would best serve the public interest.

The Commission's Bureau of Accounts is in charge of the work of preparing revised classifications for consideration by the Commission. In accordance with the usual practice in the formulation of accounting rules, co-operation was established between the Bureau of Accounts and the Railway Accounting Officers' Association. The procedure has been substantially as follows:

Tentative revisions are prepared by the Bureau of Accounts and submitted to a committee of the Accounting Officers' Association appointed to confer with the Commission's representatives. Changes recommended or suggested by the association, and tentatively accepted by the Commission's representatives, are incorporated in revised drafts of the proposed classifications, together with changes initiated by the Bureau of Accounts. The revised drafts are then considered jointly by the railway and the Commission's representatives. The proposed revisions of the classifications are sent by

the Commission to the State Commissions and to others believed to have an interest in the matter, for the purpose of eliciting criticisms and suggestions with reference to the changes proposed in the accounting rules.

In November, 1923, the Bureau of Accounts circulated copies of a tentative revision of the classification of operating expenses. The Bureau was assisted in its work by the committee appointed by the Railway Accounting Officers' Association. Prominent features of the proposed revision were: (1) adherence to the existing practice of departmental accounting; (2) a substantial reduction in the number of primary accounts; (3) transfer of various primary accounts from one general account to another; (4) a subdivision of the primary accounts as between (a) labor, (b) material, and (c) miscellaneous items; (5) exclusion of all items of rent from the expense accounts, payments for the use of property of others to be chargeable to income; (6) elimination of equalization accounts, on the ground that the function of accounts is to show facts rather than ends desired but unattained (7) a new general account V, "Other Departments and Expenses," to supplant the existing general account VII, "General," and designed along departmental lines to conform to the usual railway organization, and eliminating the present distinction between maintenance and other operating expenses; (8) a new general account VI, "Compensation for Damages," bringing together all expenses incident to the settlement of such liabilities; (9) a requirement that all service loss on property retired shall be charged to operating expenses in place of the present rule that loss on fixed property retired and not replaced is chargeable to profit and loss; (10) change in the character of the insurance accounts to make them clearing or equalization accounts through which to account for insurance recoverable, creditable under the present classification to the maintenance account appropriate for repairs of the insured property, the proposed plan thus leaving the repair accounts to show the full amount of expenditures for repairs; (11) certain new primary accounts such as, for example, "Work Train Service," to include the expense of operating work trains in maintenance work and avoid the detailed distributions required by the existing classification; "Shop Expenses," to replace with one primary account the present practice of distributing shop expenses among a number of primary accounts, thereby avoiding detailed prorations of balances in clearing accounts; 260 "Preparing Motive Power," "Preparing Cars," and "Transfer and Delivery Service," the latter account to include items now chargeable to revenue accounts where payment is made to other than common carriers, the theory being that the full expense incurred in accomplishing transportation and earning the revenues incident thereto should appear in the operating expense accounts.

In January, 1924, the Committee on General Accounts of the Railway Accounting Officers' Association expressed the view, by resolution, that the present requirements of efficient and economical railroad operations do not require an entirely new set of accounting classifications, and that any revisions or changes contemplated by the Commission in its present accounting rules should be made by amendments or changes in the present account-

ing classifications and limited to the necessary requirements of the Transportation Act of 1920, and to a consolidation, clarification or amplification of the present operating primary accounts within the general accounts. It was further stated, however, that if after consideration of this view the Commission should still feel that new accounting classifications are required, the association would give its full co-operation to that end.

In July, 1924, Commissioner Eastman advised the Accounting Officers' Association (in annual meeting) that much interest had been shown in the proposed revisions, not alone by carriers but by state commissions, organizations of shippers, banking institutions, expert accountants, and economists; and that the Bureau of Accounts, in its work of revision, had been instructed to prescribe a minimum of detail which experience has shown to be genuinely useful, but also to consult and collaborate with other bureaus of the Commission having occasion to use accounting and statistical data.

In its annual report for 1924, the Commission stated that the desired criticisms and suggestions from the carriers had been slow in forthcoming owing to difference of opinion among them. In June, 1925, Commissioner Eastman again wrote the Accounting Officers' Association stating in part that the work of revising the accounting classifications had met with considerable delay, due in part to the difficulty of obtaining an expression of views from the association in regard to changes suggested by the Bureau of Accounts; and suggesting that the Commission be given the benefit of an expression of divergent views rather than to incur further delay in an attempt to reconcile differences of opinion. The Commissioner's letter was accompanied by a memorandum from Alexander Wylie, Director of the Bureau of Accounts, which memorandum stated in part:

> "The accounting officers are not at all unanimous in their opinions as to the form the revisions of the classification of operating expenses should take. The primary accounts now prescribed, with the exception of the depreciation accounts, were adopted with substantially full concurrence of the accounting officers. Many of the Class I carriers which are using the primary accounts in a greater or less degree in connection with the carrying on and supervision of their operations do not care to have the number of accounts reduced. If fewer accounts are prescribed they will desire permission to subdivide into substantially the same number of accounts as now provided. Other carriers are of the opinion that they can get along with a greatly reduced number of accounts. One solution of the problem would be to make only the minor changes which are necessary in the primary accounts as now provided and to provide a condensed classification which might be used by Class I roads when so authorized by the Commission upon a showing that a material saving in expenses would actually be effected and the furnishing of a certification that a greater subdivision of the accounts was not necessary for the purposes of the particular railroad making the application for use of the condensed classification. This plan would doubtless lead to an investigation of the subject by all carriers and would probably impel those now asking for a condensed classification to accept one substantially in the same detail as that now in effect.
>
> "In the preparation of the classification of operating accounts it is planned to give very careful consideration to providing, so far as practicable, for the essential elements of cost accounting. It

must be recognized, of course, that the proportion of directly assignable expenses in connection with the various classes of transportation is relatively small; that the proportion of these expenses which must be assigned upon a more or less arbitrary basis is relatively large as compared with most other industries."

In its annual report to Congress for the year 1925, the Commission stated that tentative revisions of all accounting classifications for steam roads had been prepared, and that conferences with the railway accounting officers had continued.

On June 5, 1926, Commissioner Eastman again wrote the Accounting Officers' Association. His letter contained excerpts from a memorandum by Director Wylie to the effect that a revision in tentative form of the classification of operating revenues had been submitted to the carriers' committee, and advising further that:

"In addition to this classification the Classifications of Investment in Road and Equipment, Income and Profit and Loss have been in the hands of the sub-committee for a number of months.

"The general balance sheet classification is ready to hand to the sub-committee just as soon as it is in position to handle it.

"During the year the only classification which has been considered by the sub-committee with representatives of the commission is the Classification of Operating Revenues, and the consideration of this has been practically completed.

"At a meeting held May 19-20, at Washington, the Committee on General Accounts considered the classification of Operating Revenues. It also considered the Classifications of Income and of Profit and Loss Accounts without waiting until the sub-committee had given them consideration. In general the recommendations of the General Accounts Committee were constructive, and the greater part of their suggestions have been incorporated in the tentative draft of the classifications.

"From the foregoing it will be noted that during the past year only a small part of the work of reviewing the classifications by the Railway Accounting Officers' Association has been accomplished. It is very important that the work of the committee in this connection be greatly speeded up if time be afforded after their work is completed to submit the classification, as has been the practice heretofore, to the state commissions for their suggestions or criticisms, and to produce them in form for the commission's order issuing them as of January 1, 1927."

Under date of November 27, 1926, the following notice was issued by the Secretary of the Commission:

"Notice to All Concerned:

"A tentative draft of revised accounting rules for steam railroads has been prepared by the Bureau of Accounts of the Commission after conferences with committees representing the Railway Accounting Officers' Association, and this draft has been printed by that association for the use of its members. Included in this print are recommendations by committees of the association, which have not been adopted in the tentative draft. There is further included a letter of transmission to the chairman of the Commission from the Director of Accounts which contains a general explanation of the changes in the present accounting regulations which are contemplated in the draft, and also a discussion of certain of the recommendations of the accounting officers.

"The Commission is in no way committed to this tentative draft, and the members of the Commission have as yet given it no study. It is now being sent to the State Commissions and all others that there is reason to believe may have an interest in it from the public point of view, in the hope that the Commission may elicit criticisms and suggestions that will be of value in determining what changes, if any, should be made before it is finally adopted. The modifications of our present regulations, which are embodied in the draft, have been governed by the intent:

(1) To correct such deficiencies as experience, particularly in the accounting, statistical, valuation and finance branches of the Commission's work, has shown to exist in the present regulations.

(2) To eliminate all requirements that cannot be shown to be of substantial public use, in the broadest sense of those words.

"The subject of depreciation charges is being covered in a separate proceeding and such changes in the tentative draft as may be required by the order in that proceeding, which will soon be issued, will be made in the final draft.

"There may be others interested in the tentative draft to whom it has not been sent, and if copies are desired with a view to submitting criticisms and suggestions to the Commission, after study and analysis, such copies may be obtained by application at the Commission's office.

G. B. McGinty,

Secretary."

The letter referred to in the Secretary's notice is as follows:

Interstate Commerce Commission

Bureau of Accounts

Washington

November 24, 1926.

Hon. Joseph B. Eastman, Chairman,
Interstate Commerce Commission,
Washington, D. C.

Dear Mr. Eastman:

I hand you herewith, as a progress report, revised accounting rules as prepared in tentative form for steam railroads.

In pursuance of the established practice in the formulation of accounting rules, tentative revisions were first prepared by this bureau and submitted to a Committee assigned by the Railway Accounting Officers' Association to co-operate with representatives of the Commission by offering criticisms and recommendations as an aid in producing rules which, while meeting the needs of the Commission and others who use the carriers' returns, would also provide suitable records for the carriers' financial, administrative, and operating purposes. This Committee devoted much time and labor to the consideration of this matter. The rules were redrafted to incorporate in them such suggestions of the Committee as, in the judgment of the representatives of the Bureau of Statistics, the Bureau of Valuation, and the Bureau of Accounts, seemed to be appropriate. The Committee then rendered a report to the General Accounts Committee of the Railway Accounting Officers' Association indicating the recommendations which had been offered but not tentatively accepted, and submitted copies of the revised drafts of the rules.

The General Accounts Committee considered the subjects, for the most part approving the suggestions previously offered, and submitted further recommendations. The drafts that are now presented to you were then prepared. Upon pages 3 to 9 (Bulletin No. 112, Railway Accounting Officers' Association) are shown 68 recommendations of the General Accounts Committee, which are now being held for further consideration. A number of this Committee's recommendations have been incorporated in these drafts. Of the recommendations which have not been tentatively accepted, 47 relate to modifications of the effective accounting rules.

In each of the classifications the instructions have been amplified and consecutive numbers assigned to them for convenience of reference. The texts of the accounts have also been expanded to include important items which have been brought to the attention of the Bureau of Accounts since the issuance of the effective accounting rules.

The report of railway accounting officers, upon the subject of assigning operating revenues and expenses to states, is contained on pages 11 to 13 of this publication. (Bulletin No. 112, Railway Accounting Officers' Association.) In the preparation of the tentative rules, this subject has been given very careful consideration. It is my view that any showing of revenues and expenses by states, if of value, must be produced by the assignment of the details entering into the primary accounts and not by the assignment of the total amounts includible in these accounts by the individual carriers. In other words, the results are obtainable by assigning items of revenues and expenses rather than by prorating the total charges to each primary account.

Our experience has been that the assignment of expenses to determine the cost of transporting any specific class of business must be through special studies. Any attempt to show in the financial accounts of carriers currently the expenses of all classes and kinds of business carried could only be effected through imposing upon the carriers enormous burdens of expense in accounting. Care has been exercised in preparing these rules, however, to preserve the primary accounts in such form that they are equally available for cost studies as are the effective rules.

The following will indicate the more important changes which have been made in the tentative drafts as compared with the effective rules:

Road and Equipment

The total number of primary accounts has been reduced from 62 to 42. This has been accomplished by eliminating 22 accounts through consolidation of accounts carrying relatively small items of investment and by the addition of two accounts, one for sand and gravel pits and quarries, and one for unadjusted investment items.

A general account has been provided for land.

Investment in shop and power-plant machinery has been included under the general account "Equipment." This was done for the purpose of classifying the investment in and the maintenance of the property under the corresponding general accounts.

A new general account, "Investment Suspense," is provided in which to carry items held in suspense until the necessary information is obtained to assign them to the other accounts. This suspense account will permit, should it be found desirable, adjusting of primary accounts to include the carriers' investment in railway property in accordance with the basic inventory valuation cost-new,

the difference between the allowance thus distributed and the total investment to be carried in the "Unadjusted Investment" account until the final disposition of this difference is authorized by the Commission.

In the Commission's valuation, the direct costs of structures were first determined, and to these costs there were added, on a percentage basis, the overhead costs to cover expenditures such as those provided for in the proposed general expenditures group. This was necessary for the reason that in the accounting by most carriers a part of the overhead expenses had been directly included in the cost of structures, while other items of the same character had been included under general expenditures. It is the view of the Bureau of Valuation that, because of the impracticability of assigning all general expenditures to the individual units of property, such expenditures should be carried in the general account and distributed pro rata in determining the ledger value of any particular piece of property. (The Railway Accounting Committee recommends that all these expenditures be assigned to the primary accounts to which the direct costs of the structures are charged.)

The following are some of the more important recommendations of the Railway Accounting Committee with respect to this classification, which have not been tentatively accepted:

> Service value of fixed improvements *retired and not replaced* should be charged to operating expenses. (Such losses heretofore have been chargeable to profit and loss.)
>
> The discontinuation of the charges for transportation of construction material over the carrier's own line. (Various carriers are insistent upon the allowances for such expenses in connection with valuation. The valuation and the accounting departments of the railroads therefore do not seem to be in accord on the subject.)

Operating Revenues

It is provided that the carriers shall file with the Commission their plans of accruing unaudited revenues and shall make no change in practice thereafter without filing the supplementary plans with the Commission. This and similar provisions in other classifications have been inserted for the purpose of keeping the Commission informed as to the practices of carriers in such matters, and it will permit the correction of improper practices. (The Railway Accounting Committee objects to these rules for the reason that they restrict initiative and experiments.)

An account has been provided for the revenue from heating and refrigerating service. The amount of this revenue, since the present classifications were promulgated, has very greatly increased and is of sufficient volume to justify a special revenue account therefor. (The Accounting Committee recommends the elimination of this account for the reasons given under Item 26, page 5, of this publication.)

Operating Expenses

The number of accounts has been reduced from 209 to 125. This has been accomplished by the elimination of 90 accounts through consolidation of those carrying minor charges and the addition of 6 accounts to provide for equalization and amortization expenses.

The accounting committee recommended the consolidation of additional accounts. This recommendation appears under Item 29, page 6, of this publication. It is questionable whether these

consolidations would result in releasing any considerable amount of labor for other work of the carriers. The thing to be determined is whether these accounts should be continued in the accounting rules in view of the fact that a large number of carriers will desire to maintain them.

The Committee recommends that clearing accounts be eliminated for shop expenses and store expenses and that primary accounts be set up for shop expenses, store expenses and work train services. The acceptance of this recommendation would relieve the carriers of considerable labor. It would, however, render more difficult the determination of costs through special studies.

A single account for depreciation and a single account for the retirements of property are provided under each general account, "Maintenance of way and structures," and "Maintenance of equipment," but the assignment of such charges to the various classes of property should be maintained and shown in the annual reports or in special reports to the Commission as required.

The insurance accounts provide that the amounts recovered from insurance companies on account of losses shall be credited to the account to which the premiums covering the hazards have been charged. This rule would secure a showing for each and all carriers of the *net* amount charged against the revenues contributed by the public for insuring the carriers against hazards. It would also permit comparisons with respect to direct costs of maintenance, and expenses on account of personal injuries, loss and damage and similar claims, between the carriers that insure and those that do not insure, inasmuch as under the plan the total amount of such expenses will be stated in the appropriate accounts.

The primary account for valuation expenses is limited to the expenses incident to the ascertainment of the value of the carriers' property. This will require the current expenses of maintaining the carriers' records of property changes to be stated in appropriate primary accounts under general account "General."

The Accounting Committee recommended the creation of an additional general account under the title "Miscellaneous" (Item 27, page 5, of this publication), for the purpose of recording items which are now included under other general accounts.

Income

These rules provide that all rents shall be excluded from the operating accounts and included in the rent accounts in income.

The income statement has been modified to include an account for "Net railway operating income."

Balancing accounts have been provided for hire of equipment, and contributions to cover the profit and loss in operation of separately operated properties. This will permit the showing of the net results in the accounts relating to such items.

The carriers recommended (Item 45, page 7) that the "Cost of advertising bonds drawn for redemption," "Cost of trusts, current expenses of maintaining and administering," and "Losses due to conversion of funds of a foreign country into U. S. funds," shall be included as operating expenses. These items heretofore have been shown in the income statement below the "Net railway operating income."

Profit and Loss

The Accounting Committee recommends (Item 47, page 8) that the account, "Donations," shall be modified to include grants received from states, municipalities and other public corporations toward the construction or acquisition of carrier property, and

that the account, "Grants in aid of construction," shall be eliminated.

The tentative rules provide that penalties and fines for violation of the interstate commerce act or other Federal laws shall be included in profit and loss. The Accounting Committee recommends that all such items should be included in operating expenses.

Balance Sheet

In Instruction 703 (c) it is provided that verification shall be made currently of all suspense and open accounts. This rule is followed by most carriers. The provision is included for the purpose of putting all carriers on notice that this practice is mandatory. (The Accounting Committee, Item 51, page 8, recommends the elimination of this provision, but does not indicate the reason therefor.)

Provision has been made for carrying in the balance-sheet accounts for investment, the ledger value of railroads that are leased under such terms and conditions and for such duration as effectively to vest in the lessee ownership of the property. This provision is proposed in order that the returns of the carriers to the Commission may include the ledger value of property owned by inactive non-operating companies as well as all other carrier property.

The Accounting Committee recommends (Item 53, page 8) that expenses in connection with the issuance and sale of evidence of funded debt, such as fees for drafting mortgages and trust deeds, cost of engraving and printing bonds, certificates of indebtedness and other registration papers, fees paid to trustees provided for in mortgages and trust deeds, fees paid for legal services to trustees relative to mortgage securities, fees and commissions paid to underwriters and brokers for marketing such evidence of debt, specific cost of obtaining government authority to issue funded debt, and other like expenses, be included under operating expenses. These items are now classed as an expense of funded debt and included in income.

The text of the account for "Cash" provides that the carrier shall show the entire amount of cash on hand without deduction for checks, vouchers, etc., outstanding against this balance. This is for the purpose of securing uniform accounting for items included in this account.

The Accounting Committee recommends (Items 67 and 68, page 9) that accounts, "Additions to property through income and surplus," and "Funded debt retired through income and surplus," shall be eliminated. These accounts were provided for the convenience of carriers in showing invested surplus distinctly from other profit and loss balances. The labor involved to maintain the accounts is small and it is questionable that they should be eliminated.

ALEXANDER WYLIE,
Director.

In June, 1926, there had been distributed tentative classifications of investment in road and equipment, income accounts, profit and loss accounts, and operating revenues. (See Bulletin No. 111, June 1, 1926, of Railway Accounting Officers' Association.) In November, 1926, distribution was made of what were known as the October, 1926, drafts of tentative classifications of investment in road and equipment, operating revenues, operating expenses, income accounts, profit and loss accounts, and balance sheet accounts. (See Bulletin No. 112, November 15, 1926, of Railway Accounting Officers' Association.)

Under date of November 2, 1926, the Interstate Commerce Commission promulgated rules and regulations concerning depreciation charges of common carriers and issued an order relating thereto (Order No. 15100) to become effective January 1, 1928. On February 21, 1927, the Bureau of Accounts submitted tentative changes in the accounting rules providing for the administration of the depreciation order, with reference to which proposed changes there followed, between March 23 and April 22, 1927, an extended conference between the Commission's representatives and representatives of the Accounting Officers' Association. The position of the carrier's committee regarding the depreciation order and its relation to the matter of revised accounting classifications was expressed in the following resolution, which was made a matter of record:

> "WHEREAS, This Committee, has, for several years, been co-operating with the representatives of the Interstate Commerce Commission in the revision of the Accounting Rules, and the Director of the Bureau of Accounts of the Commission having presented to the Committee certain suggestions as a basis for incorporating in the tentative classification of Investment in Road and Equipment, the provisions of Order No. 15100 of the Commission regarding Depreciation Charges of Steam Railroad Companies,
>
> "RESOLVED, That the Committee deems it necessary, before proceeding to further consideration of the tentative revised accounting classifications, to state that its co-operation with the Commission, in the tentative revision of the Accounting Classifications hereafter issued by the Commission directly or through the R.A.O.A., shall not be construed as an acceptance or approval by the Committee or any member thereof of the principles contained in the Commission's Order No. 15100 and shall not prejudice the right of any carrier individually or the carriers collectively to contest any of the provisions of said Depreciation Order."

On April 25, 1927, the Bureau of Accounts submitted revised drafts of the six classifications, modified in accordance with the requirements of the provisions of the Commission's Order No. 15100. It was found that because of the changes due to the depreciation order, a number of the previous suggestions and recommendations made regarding the proposed classifications were no longer applicable. The carriers' association was advised that all others of its recommendations were being held for consideration in the preparation of the accounting rules in final form.

In June, 1927, Commissioner Eastman advised the association that the effective date of the Commission's Order No. 15100 had been advanced to January 1, 1929, and that since the revised classifications must of necessity conform with the requirements, as finally determined, of the depreciation order, both should become effective at the same time. The Commission had therefore concluded to work toward making the new classifications effective January 1, 1929. The Commissioner further advised the association as follows:

> "Your committee on revision, since your last annual meeting, has devoted a great deal of time and much labor to the tentative accounting rules and has very diligently co-operated with representatives of the bureaus of accounts, statistics, and valuation in the preparation of tentative drafts of the classifications of investment in

road and equipment, operating revenues, operating expenses, income, profit and loss, and general balance sheet accounts. We very much appreciate not only the quality and quantity of this co-operation but also the spirit in which it has been tendered. * * *

"At the time when we made public the tentative draft of the revised classification, we sent copies to all that we had reason to believe might be interested and extended a general invitation that we be given the benefit of comments and criticisms. The state commissions have individually and as a body, through general committees, devoted much time to the matter and have sent in many helpful suggestions and promise more. Many interesting communications have reached us from other sources. The interest in the subject seems, I am glad to say, to be growing. Certain shippers' organizations are working on the matter, and there have been various requests for a public hearing. Whether these will be granted remains yet to be determined. Clearly all interested parties must have full opportunity to express their views and to combat, if they so desire, the views of others, and the question is merely the best way from all points of view of affording this opportunity.

"What the Commission desires to promulgate, of course, is a classification of accounts which will impose no unnecessary and useless labor upon the carriers, but will at the same time make readily available, within practical limits, the information in regard to the operations of the carriers for which there is a real public need. And I include in this phrase the needs of the shippers, of investors, and of the carriers themselves. Manifestly as in the case of depreciation accounting, the subject is complex and difficult, and we need all the light upon it that we can obtain in order that we may act both intelligently and wisely. We shall look forward to and count upon the continued co-operation of your association."

On October 11, 1927, the Secretary of the Commission issued a general notice to the effect that the Commission had decided to make the general revision of the accounting rules for steam railroads the subject of a public hearing, to commence November 9, 1927; and to hold such hearing in connection with the further hearings in No. 15100, Depreciation Charges of Steam Railroads, and No. 14700, Depreciation Charges of Telephone Companies. The notice stated that various requests had been received for a public hearing, and that the Commission had been informed that the National Industrial Traffic League was prepared to submit a revision of the accounting rules involving a marked departure from the system of accounting now in effect. It had also been represented to the Commission that there is such interrelation between the general revision of the accounting rules and the matter of depreciation charges that the two subjects should be considered together or at least in close proximity. It was further stated that, while it seemed to the Commission that the records on the two subjects should be kept separate, although taken consecutively, it should be understood that it may prove desirable for the Commission to consider these records together, and that the subjects are sufficiently related so that the record in one proceeding may have a bearing upon the action to be taken in another. The proceeding concerning the revision of the accounting classifications is designated by the Commission ex parte No. 91.

TENTATIVE REVISIONS OF CLASSIFICATION OF INVESTMENT IN ROAD AND EQUIPMENT

March, 1926, Draft

The Bureau of Accounts in March, 1926, gave informal circulation to a tentative revision of the Road and Equipment accounts for the purposes of discussion and criticism. The proposed general and primary accounts, as compared with the accounts in the existing classification, were as follows:

General Accounts

Present	*Proposed*
I. Road	I. Land
II. Equipment	II. Fixed improvements
III. General expenditures	III. Equipment
	IV. General expenditures

Primary Accounts

I. Road	I. Land
1. Engineering	1. Land for common carrier purposes
2. Land for transportation purposes	II. Fixed improvements
3. Grading	2. Grading
4. Underground power tubes	3. Underground power tubes
5. Tunnels and subways	4. Tunnels and subways
6. Bridges, trestles and culverts	5. Bridges
7. Elevated structures	6. Ties
8. Ties	7. Rails
9. Rails	8. Other track material
10. Other track material	9. Ballast
11. Ballast	10. Tracklaying and surfacing
12. Tracklaying and surfacing	11. Right-of-way fences
13. Right-of-way fences	12. Snow and sand fences and snow sheds
14. Snow and sand fences and snow sheds	13. Crossings and signs
15. Crossings and signs	14. Station and office buildings
16. Station and office buildings	15. Roadway buildings
17. Roadway buildings	16. Water stations
18. Water stations	17. Fuel stations
19. Fuel stations	18. Equipment shops
20. Shops and enginehouses	19. Grain elevators
21. Grain elevators	20. Storage warehouses
22. Storage warehouses	21. Wharves and docks
23. Wharves and docks	22. Coal and ore wharves
24. Coal and ore wharves	23. Gas producing plants
25. Gas producing plants	24. Telegraph and telephone lines
26. Telegraph and telephone lines	25. Signals and interlockers
27. Signals and interlockers	26. Power plants
28. Power dams, canals, and pipe lines	27. Power transmission systems
29. Power plant buildings	28. Power line poles and conduits
30. Power substation buildings	29. Miscellaneous structures
31. Power transmission systems	30. Paving
	31. Roadway machines
	32. Small tools

Present

I. Road—Continued
- 32. Power distribution systems
- 33. Power line poles and fixtures
- 34. Underground conduits
- 35. Miscelleaneous structures
- 36. Paving
- 37. Roadway machines
- 38. Roadway small tools
- 39. Assessments for public improvements
- 40. Revenues and operating expenses during construction
- 41. Cost of road purchased
- 42. Reconstruction of road
- 43. Other expenditures—road
- 44. Shop machinery
- 45. Power plant machinery
- 46. Power substation apparatus
- 47. Unapplied construction materials and supplies

II. Equipment
- 51. Steam locomotives
- 52. Other locomotives
- 53. Freight-train cars
- 54. Passenger-train cars
- 55. Motor equipment of cars
- 56. Floating equipment
- 57. Work equipment
- 58. Miscellaneous equipment

III. General Expenditures
- 71. Organization expenses
- 72. General officers and clerks
- 73. Law
- 74. Stationery and printing
- 75. Taxes
- 76. Interest during construction
- 77. Other expenditures—General

Proposed

II. Fixed Improvements—Continued
- 33. Shop machinery
- 34. Power plant machinery
- 35. Unapplied construction material and supplies

III. Equipment
- 51. Steam locomotives
- 52. Other locomotives
- 53. Freight-train cars
- 54. Passenger-train cars
- 55. Motor equipment of cars
- 56. Floating equipment
- 57. Work equipment
- 58. Miscellaneous equipment

IV. General Expenditures
- 71. Organization expenses
- 72. General officers and clerks
- 73. Engineering
- 74. Law
- 75. Stationery and printing
- 76. Earnings during construction
- 77. Assessments for public improvements
- 78. Taxes
- 79. Interest during construction
- 80. Other expenditures—General
- 81. Jointly owned property—Dr.
- 82. Jointly owned property—Cr.

Changes in General Instructions

Various changes were proposed in the General Instructions, partly to clarify language, but also to incorporate certain new provisions, among which, in substance, were the following:

(a) With reference to the amount of detail in a carrier's records, the general book entries shall contain sufficient reference to the detail records to permit ready identification, and the detail records, including journal or other entries, memoranda, and all other data compiled in connection therewith, shall be filed in such manner as to be readily accessible for examination by representatives of the Commission.

(b) The company's records shall be kept in such manner as to show separately its investment in property devoted to common carrier purposes which it operates and in such property which is operated by others.

(c) The carrier's investment in uncompleted road and equipment projects shall be included in account 703, "Uncompleted Projects," and when the projects are completed and devoted to common carrier service shall be cleared to the appropriate accounts of this classification.

(d) The carrier's records shall be kept in such form that expenditures for additions and betterments may be reported separately from those for original road, original equipment, and road extensions, and shall show separately by primary accounts the expenditures under each authorized addition and betterment project.

(e) **Jointly Owned Property:** The carrier shall include the entire cost thereof in the appropriate primary accounts of this classification, and shall credit the amount borne by others to account 82, "Jointly owned property—Cr." The amount charged by others to the carrier as its proportion of the cost of jointly owned property acquired or constructed by others, shall be included in account 81, "Jointly owned property—Dr."

(f) **Cost of Construction:** The accounts for fixed improvements and equipment shall include the cost of construction of such property, including the cost of preliminary work such as sinking test holes or making soundings for tunnels, buildings and other structures; the cost of laying and taking up tracks for temporary use in construction, other than those provided for the protection of traffic during the progress of addition and betterment work.

(g) **Grading Grounds of Buildings:** The cost of grading and preparing grounds both before and after the construction of buildings, and the cost of constructing sidewalks, driveways, and fences thereon shall be included in the cost of the buildings, but the cost of restoring the grounds after addition and betterment work shall be included in the appropriate operating expense accounts.

(h) **Ledger Value of Property:** This value (at which property is carried in the property investment account) shall include not only the amount carried in the primary accounts under general accounts I, II, and III, which are provided for directly assigned elements of cost, but also equitable proportions of unassigned costs carried in the primary accounts under general account IV, "General expenditures," such as cost of engineering, interest during construction, etc.

(i) **Salvage from Retired Property** is the net value of the material recovered from property retired. In case the material is sold this net value is determined by deducting from the proceeds of the sale the cost of recovering and conditioning the material for sale. If the material is retained and again used by the carrier, the net value should be determined by deducting from the fair prices for material in its condition as again used, the cost of recovering and reconditioning. The charges for reused material shall be based upon fair prices for the material as reconditioned, due allowance being made for its secondhand condition. In no case shall the reused material be charged at prices in excess of its cost when originally acquired.

(j) When a unit of property other than land or equipment is retired from service and replaced with property (either owned or leased) of like purpose, the ledger value of the retired property shall be credited to the appropriate accounts of this classification.

(k) If so authorized by the Commission, the carrier may charge to Profit and Loss any extraordinary large item representing the cost (less net salvage) of property retired and replaced, instead of charging such item to operating expenses.

(l) **Adjustments for Converted Property:** When property such as a unit of equipment, building or other unit of fixed improvement is

converted into property of another class requiring the transfer of the investment therein from one primary account of this classification to another primary account thereof, the ledger value of the unit before conversion shall be credited to the primary account in which included and charged to the primary account appropriate for the converted unit. A corresponding transfer of the balance in the accrued depreciation account with respect to the property shall be made. The cost of conversion in amount not in excess of the estimated cost to restore the unit before conversion to its original condition shall be charged to the operating expense account appropriate for the repairs of the property before conversion. The remainder of the cost of conversion, if any, shall be charged to the primary account of this classification to which the cost of the converted unit is chargeable.

(m) **Cost of Railroad Purchased:** When the consideration for the purchase of a railroad includes not only road and equipment but also securities and other assets, the appraised value of the securities and other assets shall be deducted from the total cash consideration, and the remainder of the cash cost shall be charged to balance sheet account No. 704, "Undistributed Cost of Road Purchased." The carrier shall charge to the accounts of this classification the amounts carried in the primary accounts of the predecessor company representing the cost to it of the property purchased; the amount thus charged to these accounts being credited to Account 704.

(n) **Rehabilitation of Road Purchased:** If the fixed improvements of a railroad purchased, when acquired, are in such physical condition that it is necessary substantially to rebuild the road in order to bring it up to the standard required by the carrier, the cost of such rebuilding upon approval of the Commission shall be charged to balance sheet account, "Unassigned Cost of Railroad Purchased." A comprehensive statement of the estimated amount necessary to reconstruct the road shall be made to the Commission as soon as the estimates can be completed. In case such work is to be accomplished after the beginning of operations, the statement shall show the proportion of expenditures to be charged to operating expenses representing the service life consumed in the operation of the carrier and the amount chargeable on account of deferred maintenance in the property at the date of its acquirement. When the work of reconstruction is completed, a special statement shall be rendered to the Commission showing reconstruction expenditures classable under each primary account of this classification.

The General Instructions of the proposed classification omitted the provision in the existing classification that if the total cost of additions and betterments to any class of equipment, or any class of fixed improvements (except tracks), under a general plan, considered as a whole, is less than $200, the option may be exercised of charging the amount expended to operating expenses. It also omitted the present provision under Section 7 that if property retired and replaced with property of like purpose is of minor importance, and is replaced in kind without betterment, the replacement cost shall be charged to operating expenses without adjustment in the road and equipment accounts. It omitted the instruction in the same section that when renewals to an important building or other structure constitute the major portion of its value when renewed, the property, when taken out of service, shall be considered as retired; the renewed property to be considered as an addition, and the appraised cost thereof included in the investment accounts.

Track Accounts

In account 6, Ties, it was proposed in the tentative revised classification that if ties of a superior type are installed in place of an inferior type removed, the excess cost of the new ties over the cost at current prices (in the condition in which originally placed in the track) of the ties removed should be charged to this account. Conversely, if ties of an inferior type are laid in place of a superior type removed, the decreased cost of the new ties, below the cost at current prices of the ties removed, should be credited. The types of ties to be recognized under this provision were stated to be untreated wooden ties, treated wooden ties, steel, and concrete ties. The substitution of one kind of wood for another was not to be counted a change in type. In connection with account 7, Rails, it was proposed that if rails of a superior quality or heavier type are used to replace an inferior quality or lighter type, the excess cost of the rails laid over the cost at current prices (in the condition in which originally placed in the track) of the rails removed, should be charged to this account; and conversely, credited to this account. A similar provision was inserted in account 8, Other track material.

In account 9, Ballast, it was proposed that when cinders accumulated by the carrier are used as construction ballast, only the cost of transporting the cinders should be charged to this account; the cost of unloading to be charged to "Tracklaying and surfacing," and no charge made for the value of the cinders.

In account 10, Tracklaying and surfacing, it was proposed that charges to this account for labor installing additional elements of track construction after commencement of commercial operations, such as application of ballast or tie plates to tracks not previously ballasted or tie-plated, would be limited to the cost, computed at current prices, of such additional labor as it would have been necessary to expend had the addition been made at the time of the original construction; the remainder of the labor cost to be charged to operating expense. To operating expenses would be charged, as at present, the entire cost of applying additional or improved ballast to tracks which had previously been ballasted.

The revisions of text of the primary accounts reflect generally more specific detail regarding the accounts and the charges to be made thereto, than in the existing classification. The instructions concerning the disposition of related items are frequently amplified. This practice is also carried through the succeeding drafts issued by the Bureau of Accounts.

Land for Common-carrier Purposes

The land account, in the proposed classification, was made a separate general account with one primary account, "Land for common-carrier purposes." The explanation in the existing classification of what the land account shall include was expanded to provide also for inclusion of the cost of rights or easements to occupy permanently, for common-carrier purposes, land not purchased outright; the cost of land for storage warehouses, ballast pits, farms for experimental purposes conducted for

the purpose of increasing traffic, and for ice ponds used in securing ice for use in carrier operations. It was also amended to include proceeds from the sale of minerals, as well as timber or other improvements purchased with right-of-way as now provided for.

The list of items of expense chargeable to this account, given in account 2 of the present classification, was materially expanded to include, among other items, the following:

Fees of commissioners appointed by the court to assess damages in condemnation proceedings.

Agreed settlements in proceedings to clear or defend titles. (The cost of settlements, judgments, witness fees, and decreed court costs in proceedings in connection with defects arising subsequent to date of acquirement of property to be charged to operating expenses.)

Costs of making changes in or relocating property of others, including highways or tracks of other carriers, to avoid crossings or to secure permanent rights to locations; also the cost of securing sites for such relocations.

Cost of securing less restricted use of right-of-way, such as relief from obligation to permit highway or farm crossings.

Damages for non-fulfillment of conditions of purchase of right-of-way.

Damages to *interests* of others, arising from proximity of railroad.

Directly assignable expenses incurred in procuring passage of ordinances granting right to occupy public property with tracks.

Easements, granting right of permanent occupancy of property for transportation purposes.

Fees asssessed by public authority for issuing permits to the carrier to construct and maintain tracks, either on property owned or controlled by the carrier or on public property.

Land adjacent to roadway acquired to avoid suits for damage by fire from locomotives, slides, or similar causes.

Land for control of water sheds to obtain water for operating purposes.

Land outside of right-of-way for slopes of highways, to avoid building retaining walls in constructing undergrade or overgrade highway crossings.

Land used in diverting drainage from right-of-way to prevent damage to tracks.

Licenses to occupy land for right-of-way, the owners reserving the right to require that premises be vacated upon demand, by furnishing other locations.

Payment to vendors to secure release from restrictive provisions of original deeds.

Recording easements.

With reference to the acquisition of land in excess of that necessary for common-carrier operations, and division of the cost of the land purchased between this account and balance-sheet account "Miscellaneous physical property," the present rule was amended to provide that when that portion of the land acquired which is not, or will not in the near future, be used for common-carrier purposes, is practically worthless, it may be included in "Miscellaneous physical property" at a nominal value, for record purposes; the remainder of the cost to be included in the land account of the Road and Equipment classification as representing the cost of land for transportation purposes.

It was further provided, by notes to this account, that when land is purchased for gravel and sand pits and quarries, only its estimated residual value after the gravel, sand or stone shall have been removed, shall be included in this account; that when land is rented primarily in connection with addition and betterment projects, pending actual purchase, and is later purchased for such projects, the rent paid, minus any rent received from subtenants, shall be included in this account; that payments for options and of interest on options and on contracts to purchase land proposed to be used in contemplated construction shall be carried in balance-sheet account "Other unadjusted debits" pending determination as to whether the project will proceed, and if it be decided to proceed with the project, the balance in balance-sheet account "Other unadjusted debits" shall be cleared by a charge to this account, and if the project does not proceed the amount lost, including the interest, shall be charged to operating expense account 277, "Other expenses," or to profit and loss account "Miscellaneous debits," as appropriate.

It was further provided that should the cost of removal of timber or improvements purchased with right-of-way exceed net proceeds if and when subsequently sold, the net debit should be included in account 3, "Grading." When timber or other material acquired with the land is used for construction or operating purposes, its value would be credited to this account and debited to the appropriate account according to the use made thereof.

When property has been purchased for right-of-way of a proposed extension and the project definitely postponed before construction work commences, it was proposed that the cost of the property be transferred to balance-sheet account "Miscellaneous physical property," sufficient details being included in the entry to permit classification of the various items of cost in case the work is resumed; the cost of engineering work which may have been done to be included in balance-sheet account "Other unadjusted debits" until decision is made as to the execution or abandonment of the project, when it shall be included in investment account "Engineering" or profit and loss account "Miscellaneous debits," as appropriate.

Expenditures for condemning property for extensions of line would be included, pending purchase, in balance-sheet account "Other unadjusted debits," and transferred to this account when the property is purchased. In cases of abandonment of the project before purchase of the property, the amount in suspense would be cleared to profit and loss account "Miscellaneous debits."

Amounts received for easements or permanent rights to use the right-of-way, such as, for example, a permanent right to build, maintain and operate telegraph, telephone, or pipe lines thereon, and the right to use roadways and footpaths across the right-of-way, would be credited, under the proposed classification, to this account, to an extent not exceeding the cost of the property involved; any excess over such cost to be credited to profit and loss account "Profit on road and equipment sold."

It was further provided that the cost of land purchased for transportation purposes along lines held under long-term lease, or lines of controlled companies, and used in common-carrier operations of those lines, should be included in this account.

CLASSIFICATION OF INVESTMENT IN ROAD AND EQUIPMENT RECOMMENDED BY COMMITTEE ON GENERAL ACCOUNTS OF THE RAILWAY ACCOUNTING OFFICERS' ASSOCIATION

On May 19-20, 1926, the committee on general accounts of the Railway Accounting Officers' Association recommended to the Commission a proposed classification of investment in road and equipment consisting of but three primary accounts:

Account 1, "Road."
Account 2, "Equipment."
Account 3, "Investment Suspense."

The proposed classification was submitted to the representatives of the Commission for their consideration. A complete copy as printed in Bulletin No. 111, Railway Accounting Officers' Association, follows:

CLASSIFICATION OF INVESTMENT IN ROAD AND EQUIPMENT OF RAILROADS

Recommended by the Committee on General Accounts of the Railway Accounting Officers' Association, Washington, D. C., May 19-20, 1926

(A) General Instructions

1. Purpose of the Classification

(a) This classification prescribes a basis for recording, by projects, the detail of charges for investment in property held for or used in the service of transportation includible in account 701, "Investment in road and equipment."

(b) The carrier's investment in land and improvements thereon, other than that described in (a), shall be charged to account 705, "Miscellaneous physical property."

2. Accounts for Investment in Road and Equipment

(a) The accounts herein prescribed are designed to show the investment of the carrier in property held for or used in the service of transportation, and the carrier's investment in uncompleted road and equipment projects.

(b) The investment in property held for or used in the service of transportation shall be classified as follows:

Account No. 1, "Road."
Account No. 2, "Equipment."
Account No. 3, "Investment suspense."

3. Records

(a) The records shall be kept in such form as to show the expenditures under each construction project; also to show by projects the property retirements.

(b) Such records shall be kept to show the facts pertaining to entries in the accounts for investment in road and equipment. Where the information is not recorded in the general books, the entries shall be supported

by records in which the details shall be shown. Such general entries shall contain sufficient reference to detail records to permit identification; and the detail records, including journal or other entries, memoranda and all other data compiled in connection therewith, shall be filed in such manner as to be accessible for examination by representatives of the Interstate Commerce Commission, and shall be retained in accordance with the effective Regulations to Govern the Destruction of Records, promulgated by the Commission.

(c) An authority for expenditure shall be prepared for each project and shall, as far as possible, be issued in advance of the work. Such authorities shall not overlap valuation section limits, and shall describe fully the location and kind of work to be done. Blanket authorities may be issued for minor items in each valuation section.

(d) A register shall be established in which a record shall be kept by consecutive numbers, with appropriate state and valuation section reference, of all authorities for expenditure issued.

(e) Upon the completion of a project a completion report shall be prepared and attested under oath by the official under whose direction it was prepared, which shall show a reference to the authority for expenditure, the ownership of the facilities covered and by whom operated, the location and description of the work, by whom the costs are borne, and the aggregate cost of the project. This aggregate cost shall be distributed to show the units of labor, material and miscellaneous expenditures, and shall be used as a basis for transfer from "Investment suspense" to the accounts "Road" or "Equipment."

4. Definitions

(a) Construction includes all processes connected with the acquisition, formation, additions to and betterments of property held for or used in the service of transportation.

(b) Additions are additional facilities, such as additional tracks, buildings, bridges and other structures; additions to such facilities, such as extensions to existing tracks, buildings and other structures; additional ties laid in existing tracks; additional equipment; and additional devices applied to existing equipment.

(c) Betterments are improvements of existing facilities, the objective being greater usefulness or increased capacity, such as the substitution of steel-tired wheels for cast wheels, the application of heavier rail in tracks, and the strengthening of bridges. The amount chargeable to these accounts is the excess cost of new parts over the cost at current prices of new parts of the kind retired. All labor costs incurred in installation of betterments shall be charged to operating expenses.

(d) Cost shall be actual money cost, or its equivalent, entering into the project. No deductions shall be made in stating project costs where contributions have been made by states, municipalities or other public corporations (see account 754, "Grants in aid of construction"), or in cases where contributions have been made by individuals or companies (see account 606, "Donations"). The construction of a railway, highway or other crossing, station, yard or other facility, and the elimination of grade crossing or other project in which the physical property of two or more carriers or a carrier or carriers and a governmental body is concerned, and the cost of such construction is met jointly by the several parties shall be considered a joint project; the carrier's portion only of the cost shall be included in these accounts.

5. Basis of Charges and Credits

(a) Charges shall be based upon the cost of the property acquired or constructed. When the consideration given for the purchase or the improvement of property is other than money, the money value of the consideration at the time of the transaction shall be included in these accounts, and the

actual consideration shall be described in the record in sufficient detail to identify it.

(b) Credits shall be based upon the cost, estimated if not known, of the property permanently retired from the service of transportation.

6. Minimum Charges and Credits

When the total cost of additions to and betterments of, or retirements of, fixed improvements and equipment (except land and tracks), under a general plan, considered as a whole, is less than $200, the amounts involved shall be charged to the appropriate operating expense accounts. This rule is not to be construed as authorizing the parceling of expenditures in order to bring them within this limit.

7. Construction Costs

Construction costs are those incident to the acquisition of land, and the acquisition or construction of fixed improvements and equipment. The costs include also, expenditures on account of labor, materials and supplies, work train service, special machine service, transportation, contract work, injuries, damages and casualties, privileges, interest during construction, general expenditures, assessments for public improvements and other analogous elements in connection with such work.

8. Expenses in Connection with Additions and Betterments

Costs of removing old material from fixed property and equipment, removing foundations, filling excavations and restoring grounds, rearranging and relocating tracks, telegraph and telephone lines, fences, signals, buildings, bridges, trestles, highway and other crossings, crossing gates and signs and maintaining and protecting traffic during the progress of the work, shall be charged to operating expenses.

9. Accounting for Railroad Purchased

There shall be included in these accounts the cash cost of any road or portion thereof purchased. Where the contract of purchase includes not only road, but also equipment, securities and other assets, the appraised value of such equipment, securities and other assets shall be deducted from the total cash cost, and the remainder of the cash cost shall be charged to this account. Where the consideration given for the property purchased is other than cash, such consideration shall be valued on a current cash basis. If the consideration includes the assumption of liabilities, such liabilities shall be included in the determination of the cost at their cash value at the time the contract is made.

10. Rehabilitation of Railroad Purchased

When a road is purchased and the property acquired is in such physical condition that it is necessary substantially to rebuild to bring it up to the standard required by the carrier, the cost of such rebuilding shall be charged to these accounts.

11. Accounting for Leased Railway Property

(a) When contracts are drawn for a specific term of years and/or contain renewal clauses virtually continuing the agreement in perpetuity, the accounting shall be substantially the same as if the ownership of property leased were vested in the lessee. Lessee shall include in account 701, "Investment in road and equipment," and concurrently credit to new balance sheet account under "Other deferred liabilities," "Road leased from others—book value," an amount equal to the sum recorded in account 701, "Investment in road and equipment," on the lessor company's books. Lessor shall concurrently close account 701, "Investment in road and equipment," and transfer to new balance sheet account under "Other deferred assets," "Road leased to others—book value," the amounts representing the property so leased.

(b) When the lessee company is required under the terms of such contracts to assume the cost of additions to or betterments of the lessor's property, the cost thereof shall be included by the lessee in account 701, "Investment in road and equipment." When such additions and betterments are retired prior to the expiration of the contract, the lessee shall credit the original cost of the improvements to account 701, "Investment in road and equipment," and concurrently charge to depreciation reserve account, if any, an amount equal to the credit therein applicable to the property retired; the residual value (or salvage) shall be accounted for in accordance with the disposition thereof. The original cost, less the amount charged to depreciation reserve account and the residual value (or salvage), plus the cost of demolition, shall be charged to operating expenses.

(c) Where the contract provisions specify that improvements made by lessee upon lessor's property revert to lessor at the termination of the agreement and such improvements are in the service of transportation at the date of contract expiration, a joint appraisal shall be made of the improvements and the estimated appraised value shall be included by the lessor in account 701, "Investment in road and equipment," and concurrently credited to "Profit and loss." The lessee company shall consider the reversion as a retirement and account for same as set forth in paragraph (b).

(d) When the contract requires that additions and betterments are to be made by the lessor to property leased, maintained and operated by lessee, without obligation for reimbursement by lessee, the cost thereof shall be included in lessor's account 701, "Investment in road and equipment." If contractual provisions are as stated in paragraph (a) hereof, the accounting shall be as prescribed in that paragraph.

(e) When the lessee is obligated, under the terms of the agreement, to reimburse lessor, either currently or at expiration of contract, for retirement of original property acquired, the lessee, upon retirement of facilities, shall credit account 701, "Investment in road and equipment," with the original cost, estimated if not known. Concurrently, there shall be charged by the lessee to new balance sheet account under "Other deferred liabilities," "Road leased from others—book value" an amount equal to the depreciation reserve if any, upon the lessor's books at the date of the lease; and there shall be charged to the depreciation reserve, if any, on lessee's books an amount equal to the credit therein applicable to the property abandoned; salvage shall be accounted for in accordance with the disposition thereof; the difference between the original cost and the total depreciation accrued by lessee and lessor and the value of salvage recovered, plus cost of demolition, shall be charged to operating expenses. Lessor shall concurrently charge depreciation reserve account, if any, with an amount equal to the credit therein applicable to the property abandoned and credit new balance sheet account under "Other deferred assets," "Road leased to others—book value."

12. Delayed Investment Accounting

When projects are completed and enter the service of transportation and for any reason the accounting has not been accomplished, carriers are permitted to include in account 1, "Road," and account 2, "Equipment," the actual cost, if known, or the estimated cost of the project. Concurrently, the cost shall be credited to account 3, "Investment suspense," to which account expenditures during the progress of the work and delayed charges shall be made. Upon completion of accounting, any adjustment necessary shall be made in the investment accounts.

13. Salvage from Retired Property Retained and Used

When material is retained and again used in construction or in addition and betterment projects, the value shall be established upon the basis of current market prices of new material of the same kind, less a suitable allowance for service loss.

14. Disposition of Retirement Charges

In order that operating expenses for a current period may not be unduly distorted by including charges covering extraordinarily large retirements, carriers may, upon filing notice with the Interstate Commerce Commission, anticipate such charges by creating reserves against the time of retirement, or may suspend such charges for a period not exceeding three years after retirement to be absorbed in operating expenses by equal monthly charges during the period of suspension.

15. Submission of Questions

To the end that uniformity of accounting may be maintained, carriers are invited to submit questions of doubtful interpretation to the Commission for consideration and decision.

Text Pertaining to the Accounts

(B) Account 1, "Road"

1. To this account shall be charged the cost of land held for or used in the service of transportation and of fixed improvements thereon, such as grading, ballast, tunnels, subways, bridges, tracks and appurtenances, fences, crossings, signs, buildings, stock yards, grain elevators, signals, interlocking plants, automatic train control and car retarder systems, warehouses, docks, wharves and other structures, telephone and telegraph lines, power plants, power transmission and distribution systems, maintenance of way and equipment machines, such as tractors, motor, hand and push cars, machinery and specialties mounted on equipment exclusively assigned for use in and about shops, storehouses, stations, roadway and other similar service for maintenance of way and equipment forces, and small tools and all other property with machinery, fixtures and appurtenances necessary to equip for service, assessments for public improvements and taxes and interest during construction; also the cost of additions to and betterments of such property.

2. There shall be credited to this account the cost, estimated if not known, or property sold, dismantled or otherwise permanently retired from the service of transportation. The amount of the credit shall be concurrently charged in accordance with the disposition of the property.

Items to be Charged and Credited

3. The cost of acquisition and the cost of rights or easements to occupy permanently land required for roadway, station, office, shop, storage, warehouse and other structures; for ingress to or egress from such facilities; for borrow pits, waste banks, ballast pits, snow fences, sand fences and other railway appurtenances; for experimental farms; for ice ponds; for storage of material and for wharves and docks including riparian or water rights; and the cost of removing from the right-of-way and locating elsewhere the property of others, including the cost of land for relocation of such property, shall be included in this account.

4. When land is purchased and any substantial part of it is not held for or used in the service of transportation, that part not held for or used in the service of transportation shall be appraised and included in account 705, "Miscellaneous physical property," at its appraised value.

5. When land is rented to facilitate construction and addition and betterment projects, the rent paid, less any rent received from subtenants, shall be included in this account.

6. Payments for options and of interest on options and on contracts to purchase land for contemplated construction and addition and betterment projects, shall be carried in account 727, "Other unadjusted debits," pending disposition. Upon exercise of options or contracts, the balances in account 727, "Other unadjusted debits," for such projects shall be cleared

to the accounts of this classification; otherwise the amounts involved shall be charged to account 277, "Other expenses."

7. Preliminary surveys and reconnaissances for contemplated construction and addition and betterment projects shall be carried in account 727, "Other unadjusted debits," pending disposition. When the project is constructed, the amount shall be cleared from account 727, "Other unadjusted debits," and charged to this account. If abandoned, the amount shall be charged to account 277, "Other expenses."

8. Cost of labor includes the pay, office and other expenses of the carrier's forces (see section 15 of special instructions for operating expense accounts); also the cost of fidelity bonds and employers' liability insurance premiums. When officers or members of their staffs are specially assigned to construction work, their pay, office and other expenses while thus engaged shall be included in the cost of the project to which assigned.

9. Cost of materials and supplies includes the purchase price, plus freight charges paid to others; the cost of inspection and loading assumed by the carrier; and store expenses. (See sections 16 and 17 of special instructions for operating expense accounts.) Proper allowance shall be made for the value of salvage, such as cuttings, turnings, borings, material recovered from temporary tracks, scaffolding, cofferdams and other temporary structures used in construction; and for the value of small tools recovered.

10. Work train service includes the pay and expenses of enginemen, trainmen and other employees, including crews held or deadheading for such service; the cost of fuel and other supplies; enginehouse expenses on account of locomotives in such service; expenditures for rent and maintenance of equipment of others; and maintenance of the carrier's own equipment. When owned equipment is specifically assigned to projects, rental shall be charged therefor, based upon a fair percentage of the value of the equipment thus assigned during the construction period. Such rentals shall be concurrently credited to "Income." Where work train service involves expenditures chargeable both to operating expenses and to investment in road and equipment accounts, an apportionment shall be made between the accounts affected.

11. Special machine service includes the cost of labor and of materials and supplies consumed in maintaining and operating steam shovels, rail unloaders, ballast unloaders, pile drivers, dredges, ditchers, weed burners and other machines; also expenditures for rental and maintenance of machines of others. When owned equipment is specifically assigned to projects, rental shall be charged therefor, based upon a fair percentage of the value of the equipment thus assigned during the construction period. Such rentals shall be concurrently credited to "Income." When a construction project necessitates the purchase of special equipment, the cost thereof, less appraised or salvage value at time of release, shall be included in the project.

12. Transportation includes only the amounts paid to others for the transportation of men, materials and supplies, special machine outfits, appliances and tools in connection with construction.

13. Contract work includes amounts paid companies, firms or individuals for work performed under contract; also costs incident to the award of the contract.

14. Injuries, damages and casualties include expenditures on account of protection, injuries to persons and damage to or loss of property when incident to construction projects; also that portion of insurance premiums applicable to the period prior to the completion of the project. Recoveries shall be credited to the project.

15. Privileges include payment for temporary use of public property or streets in connection with construction projects.

16. Interest during construction includes reasonable charges for inter-

est on expenditures during the construction period before the project becomes available for the service of transportation.

17. General expenditures, such as organization and law expenses, special engineering expenses and pay and expenses of general officers and staffs, when specially assigned to the work, shall be allocated to the projects. When such expenditures cannot be directly allocated they shall be apportioned to the projects upon an equitable basis.

18. Assessments for public improvements shall be treated as projects and shall include, coincident with the completion thereof, the entire costs, regardless of the parceling over future years of assessment maturities. When assessments are deferred, the amount shall be concurrently credited to account 770, "Other deferred liabilities." Deferred interest payments, penalties, etc., shall not be included in this account. Assessments on property carried in account 705, "Miscellaneous physical property," shall be charged to that account.

19. Property retired includes land and improvements thereon and other facilities removed from the service of transportation. The amount of the credit shall be concurrently charged in accordance with the disposition of the retired property. If property other than land is definitely abandoned, the cost, estimated if not known, shall be credited to account 701, "Investment in road and equipment;" and an amount equal to the credit balance in the depreciation reserve, if any applicable to such property, shall be charged to the reserve account; the remainder, less salvage, together with the cost of demolition, shall be charged to operating expenses. When land is retired from the service of transportation, the cost, estimated if not known, shall be credited to account 701, "Investment in road and equipment," and (if retained by the carrier) concurrently charged to account 705, "Miscellaneous physical property."

20. Property replaced, rebuilt or converted includes the substitution of facilities (other than land), such as a section of main, side, yard or other track, shop or power plant building or machine, or other structures for facilities of like purpose replaced, rebuilt in kind or converted. The accounting therefor shall be upon the Betterment basis as prescribed in paragraph 4 (c) of General Instructions. Additions involved shall be accounted for as prescribed in paragraph 4 (b) of General Instructions.

21. When, due to track construction, expenses are incurred in removing and replacing public highway paving the cost of which is not included in account 701, "Investment in road and equipment," the expenses shall be included in this account. If the cost of the old paving is included in account 701, "Investment in road and equipment," the cost of removing and replacing shall be included in account 267, "Paving."

22. When a tunnel is converted into an open cut, there shall be charged to the project the cost of grubbing, clearing and actual open cut excavation. There shall be credited to account 701, "Investment in road and equipment," the cost, estimated, if not known, of the portion of the tunnel abandoned.

23. Expenditures for temporary trestles required for fills, bridges, etc., shall be included in the cost of the project. The salvage recovered when the project enters the service of transportation shall be credited to this account and accounted for in accordance with the disposition made thereof.

24. The cost of ties, rails and other track material used in the construction of car floats shall be included in the cost of such floating equipment.

25. The cost of ties, rails, other track material and ballast used in the construction of temporary tracks, such as gravel-pit and quarry tracks, shall be included in the appropriate clearing accounts under account 716, "Materials and supplies."

26. When cinders accumulated by the carrier are used as ballast, or otherwise, in construction or addition or betterment work, the cost of

unloading, also the cost of reloading if previously wasted, shall be charged to this account. No charge shall be made for the value of such cinders.

27. Labor in connection with the installation, after the commencement of commercial operations, of tie plates, anti-creepers and additional ballast shall be charged to account 220, "Track laying and surfacing."

28. Payments for the right to erect snow fences on land adjacent to the right-of-way shall be included in this account if the rights are in perpetuity; if for temporary rights, they shall be included in account 223, "Snow and sand fences and snowsheds."

29. The cost of signs and monuments marking the boundaries of land not used for transportation purposes shall be included in account 705, "Miscellaneous physical property."

30. The cost of structures located off the right-of-way, not held for or used in the service of transportation, shall be included in account 705, "Miscellaneous physical property."

31. The cost to the carrier of installing cross arms on pole lines owned by others, under agreements vesting in the owners of the pole lines a partial interest in the cross arms, shall be included in this account.

32. Investment in buildings and machinery of detached plants producing power both for operating purposes and for sale shall be included in this account. When plants are intended and used solely for producing power for sale, the investment shall be included in account 705, "Miscellaneous physical property."

33. This account shall include the cost of small tools provided for maintenance of way and structures or maintenance of equipment at the time the road, extension thereof or addition thereto enters the service of transportation. The cost of small tools acquired subsequently shall be charged to the appropriate accounts in operating expenses.

34. Expenditures for disposing of material excavated shall be considered a part of the cost of the project, except where such material is used for filling, the cost of loading, hauling and dumping shall be apportioned between the projects in connection with which the removal and filling occurs.

35. When machinery or other roadway property, the title to which will rest with the carrier at the expiration of contract, is acquired upon a deferred payment or rental plan, the cost, less interest, shall be charged to this account. The amounts of the deferred payments shall be concurrently credited to account 770, "Other deferred liabilities," and cleared as payments are made.

36. Proceeds from the sale of timber or surface improvements purchased with land to be held for or used in the service of transportation, less any expenses incurred, shall be credited to the cost of the property acquired. In no case shall the cost of the property be reduced to an amount below a fair value (not in excess of original cost) of the property at date of acquisition; the excess received in the sale of timber or improvements over such fair value shall be credited to "Profit and loss." Royalties from oil or mineral rights received from property owned shall be credited to "Profit and loss."

37. When land is purchased for gravel and sand pits and quarries, only the estimated residual value after removal of the gravel, sand or stone shall be included in this account. The difference between the cost and the residual value shall be charged to a suspense account under account 716, "Materials and supplies," and cleared as provided in section 11 of special instructions for operating expense accounts.

(C) Account 2, "Equipment"

1. To this account shall be charged the cost of all equipment owned by the carrier or held under equipment trust agreements or contracts for purchase, such as steam locomotives, electric locomo-

tives, internal combustion locomotives, motor-propelled train cars, passenger-train cars, freight-train cars, work equipment, floating equipment, auto buses, auto trucks, horses and harness and other miscellaneous equipment held for or used in the service of transportation, and the necessary appurtenances, including automatic control appliances, furniture and fixture first to equip, including the cost of inspection, setting up, trying out and transportation over foreign lines; also the cost of additions to and betterments of such equipment.

2. There shall be credited to this account the cost, estimated if not known, of equipment sold, dismantled or otherwise permanently retired from the service of transportation. The amount of the credit shall be concurrently charged in accordance with the disposition of the equipment.

Items to Be Charged or Credited

3. Cost of labor includes the pay, office and other expenses of the carrier's forces (see section 15 of special instructions for operating expense accounts); also the cost of fidelity bonds and employers' liability insurance premiums. When officers or members of their staffs are specially assigned to construction of equipment, additions to and betterments thereof, their pay, office and other expenses while thus engaged shall be included in the cost of the equipment.

4. Cost of materials and supplies includes the purchase price, plus freight charges paid to others, the cost of inspection and loading assumed by the carrier and store expenses. (See sections 16 and 17 of special instructions for operating expense accounts.) Proper allowance shall be made for the value of salvage, such as cuttings, turnings, borings, material and small tools recovered.

5. Transportation includes only the amounts paid to others for the transportation of equipment to the lines of the carrier.

6. Contract work includes amounts paid companies, firms or indivduals for work performed under contract; also costs incident to the award of the contract.

7. Injuries, damages and casualties include expenditures on account of protection, injuries to persons and damage to or loss of property when incident to equipment construction projects; also that portion of insurance premiums applicable to the period prior to the completion of the project. Recoveries shall be credited to the project.

8. Interest during construction includes reasonable charges for interest on expenditures during the construction period before the equipment becomes available for the service of transportation.

9. General expenditures, such as organization and law expenses, special engineering expenses and pay and expenses of general officers and staffs specially assigned to the work, shall be allocated to the equipment projects. When such expenditures cannot be directly allocated they shall be apportioned to the projects upon an equitable basis.

10. Property retired includes equipment sold, dismantled or otherwise permanently removed from the service of transportation. When a unit of equipment is retired, the cost, estimated if not known, shall be credited to this account and an amount equal to the credit balance in the depreciation reserve applicable to such unit of equipment shall be charged to the reserve account; the remainder, less salvage, together with the cost of demolition, shall be charged to operating expenses, and the value of salvage recovered accounted for in accordance with disposition thereof.

(D) Account 3, "Investment Suspense"

1. This account is provided for inclusion of charges during the progress of large construction projects, or additions to and betterments of property

where in the ordinary course the formation thereof will extend over an indefinite period. Expenditures for fixed improvements and additions and betterments, such as heavier rail laid in replacement or devices added to equipment, etc., which go into service coincident with their construction or placement, may be charged direct to account 1, "Road," or 2, "Equipment," as appropriate, and not to this account.

2. This account shall include suspense credits due to the inclusion in account 701, "Investment in road and equipment," actual or estimated costs of projects which are complete and have entered the service of transportation but for which complete accounting has not been accomplished. See paragraph 12 of General Instructions.

3. This account shall be cleared and account 1, "Road," or 2, "Equipment," as appropriate, charged with the cost of projects which are held for or have entered the service of transportation and for which the accounting has been accomplished, either actually or as permitted in paragraph 12 of General Instructions.

STATEMENT BY DIRECTOR, BUREAU OF ACCOUNTS

Explanatory of the situation then existing with reference to a revision of the road and equipment classification, the Director of the Commission's Bureau of Accounts, by letter, in June, 1926, advised the Accounting Officers' Association as follows:

> "The responsibility for the preparation and promulgation of the accounting rules under the Interstate Commerce act being with the commission, the plan of procedure adopted in the preparation of the effective classifications was that the classifications in tentative form were first prepared in the offices of the commission. They were then submitted to the Committee on General Accounts of your association and frequent conferences were held and changes made in accordance with helpful suggestions from that committee or special sub-committees thereof.
>
> "You will doubtless recall that I stated to the Committee on General Accounts at its last meeting that it was the intention of the commission to continue this plan of procedure and that the recommendations and suggestions from your association, its committees, or individual members thereof, would be received as being directed to the several classifications as they are promulgated in the tentative form for suggestions and recommendations.
>
> "The proposed road and equipment rules submitted by the Committee on General Accounts will therefore be considered as relating to the tentative classifications which were submitted to the sub-committee of your association, and were reproduced by it in the form as presented. With the exception of comparatively few items, the rules proposed by your committee are taken from or conform to the rules as shown in the tentative draft of the commission. It is only the exceptional features that are therefore to be considered. These special features are in substance as follows:
>
> > "(1) All expenditures to be classified under account 1, 'Road,' account 2, 'Equipment,' and account 3, 'Investment suspense.'
> >
> > "(2) Loss on fixed improvements retired and not replaced to be charged to operating expenses.
> >
> > "(3) Accounting for the replacement of fixed improvements to be upon the 'betterment' basis.
> >
> > "(4) No charges to investment account for transporting construction material in transportation service trains.

"In accordance with the plan which I understand it is the intention of the Committee on General Accounts to follow, the way will be open for further discussion of these four important particulars as the consideration of the tentative Classification of Investment in Road and Equipment progresses with the sub-committee, with the Committee on General Accounts, and with the association itself after all classifications have been put in a more nearly final form.

"I trust that the foregoing will make entirely clear the situation with respect to this classification."

JUNE, 1926, DRAFT ISSUED BY BUREAU OF ACCOUNTS

In June, 1926, the Bureau of Accounts issued another draft of a proposed Road and Equipment classification, the substance of which was not materially different from its earlier draft (March, 1926) except to add a general account V, "Investment Suspense," to include four primary accounts as follows:

91, Road and equipment under construction.
92, Unapplied construction material and supplies.
93, Unadjusted investments.
94, Road purchased—unassigned.

Under general accounts II and III, "Fixed Improvements" and "Equipment," respectively, the arrangement of the accounts of the present classification and the present account numbers were restored, except for the omission of the following accounts of the present classification, which in each instance were either to be absorbed in other primary accounts or transferred to general accounts IV and V, "General Expenditures" and "Investment Suspense:"

1, Engineering (to be account 73 under General Account IV).
4, Underground power tubes.
7, Elevated structures.
28, Power dams, canals and pipe lines.
30, Power sub-station buildings.
32, Power distribution systems.
34, Underground conduits.
39, Assessments for public improvements (to be account 77 under General Account IV).
40, Revenues and operating expenses during construction (to be replaced by proposed account 76, "Earnings During Construction," under General Account IV).
41, Cost of road purchased (to be account 94 under "Investment Suspense," a temporary clearing account).
42, Reconstruction of road purchased (to be charged to proposed account 94 until cleared to primary accounts).
43, Other expenditures—Road.
46, Power sub-station apparatus.
47, Unapplied construction material and supplies (to be account 92 under "Investment Suspense").
55, Motor equipment of cars.

Under "General Instructions," there appeared a provision that when the total cost of additions and betterments to any class of equipment or fixed improvements (except additional track) does not exceed $100, it may be

charged to operating expenses; the carrier being permitted to fix a limit less than $100 providing it so advise the Commission and make no change therefrom except upon authority of the Commission. Regarding the cost of removing old material and equipment from buildings, bridges and other fixed improvements, there was inserted a provision that the cost of applying new parts for betterment purposes shall be charged to the appropriate operating expense accounts. Regarding the proposed account 94, "Road Purchased, Unassigned," under "Investment Suspense," it was proposed that expenditures thus charged be cleared only under specific instructions of the Commission.

OCTOBER, 1926, DRAFT

Another tentative draft of the investment classification was circulated by the Bureau of Accounts in October, 1926. The general and primary accounts proposed in this draft were as follows:

General Accounts

I. Land
II. Fixed improvements
III. Equipment
IV. General expenditures
V. Investment suspense

Primary Accounts

I. Land
  1. Land for transportation service
  2. Public improvements

II. Fixed improvements
  3. Grading
  4. Tunnels and subways
  5. Bridges
  6. Ties
  7. Rails
  8. Other track material
  9. Ballast
  10. Tracklaying and surfacing
  11. Fences, snowsheds, crossings and signs
  12. Station and office buildings
  13. Roadway buildings
  14. Fuel and water stations
  15. Equipment shops
  16. Wharves
  17. Telegraph and telephone lines
  18. Signals and interlockers
  19. Power plants
  20. Power transmission systems
  21. Miscellaneous structures
  23. Roadway machines and tools

III. Equipment
  51. Locomotives
  52. Freight cars
  53. Passenger-train cars
  54. Floating equipment
  55. Work equipment
  56. Miscellaneous equipment
  57. Shop machinery
  58. Power plant machinery

IV. General Expenditures
  71. Organization expenses
  72. General officers and clerks
  73. Engineering
  74. Law
  75. Stationery and printing
  76. Earnings during construction
  77. Taxes
  78. Interest during construction
  79. Other expenditures—General

V. Investment Suspense
  91. Unadjusted investments
  92. Road purchased—Unassigned

In account 6, Ties, the provision inserted in the previous drafts to the effect that if ties of a superior type are used to replace ties of an inferior type, the excess cost may be charged to this investment account, and con-

versely if ties of an inferior type are used to replace ties of a superior type the difference shall be credited, was in this draft omitted; the similar provisions, however, in the account "Rails" and "Other Track Material" being retained.

Several changes were made in the "General Instructions," among which were the following:

(a) The previously proposed instruction that, "the accounting companies' records shall be kept in such a manner as to show separately its investment in property devoted to common carrier purposes which it operates and in such property which is operated by others," was omitted.

(b) There was inserted a new provision that the classification of property between carrier and non-carrier shall be consistent with the carrier's classification for valuation purposes.

(c) Regarding donations, a provision was inserted to the effect that the carrier shall charge to the investment classification the current cash value of property donated by others for transportation service and also the cost of carrier property acquired through the expenditure of donations of cash or its equivalent.

(d) A new instruction entitled "Property Changes" was inserted, providing that: To the accounts of this classification shall be charged the cost of all carrier property acquired, including property purchased, property constructed by or for the carrier, impovements made to existing property, and of property transferred from noncarrier to carrier use. To these accounts shall be credited the ledger value of all carrier property retired.

(e) In "Property Changes," it was proposed, "for reasons of practicability and to avoid undue refinement in accounting," (1) that when new parts applied in connection with maintenance have a greater or less capacity or durability than those removed, there shall be charged or credited the difference between the cost of new parts and the current value of the parts retired; (2) that charges shall be made to operating expenses for carrier property (except land or tracks) acquired under a general plan considered as a whole, when the total cost does not exceed $200, with permission to adopt a limit of less than $200 providing the Commission be notified of the maximum amount proposed to be used and no subsequent changes in practice be made except by authority of the Commission; (3) that adjustments in these accounts shall be omitted when property (other than land or tracks) is retired and replaced, if the cost of replacing and the ledger value of the property retired are each within the limit of $200.

APRIL 26, 1927, DRAFT

Under date of April 26, 1927, the Bureau of Accounts submitted a new draft of a tentative investment classification, designed to give effect to the provisions of the Commission's depreciation order as well as to incorporate the results of a further consideration of the proposed revisions. The general and primary accounts proposed in the latter draft are as follows:

General Accounts

I. Land for transportation service
II. Fixed improvements
III. Equipment
IV. General
V. Investment suspense

Primary Accounts

I. Land for transportation service
  1. Land
  2. Public improvements

II. Fixed improvements
  3. Grading
  4. Tunnels and subways
  5. Bridges
  6. Ties
  7. Rails
  8. Other track material
  9. Ballast
  10. Tracklaying and surfacing
  11. Fences, snowsheds, crossings and signs
  12. Station and office buildings
  13. Roadway buildings
  14. Fuel and water stations
  15. Equipment shops
  16. Wharves
  17. Telegraph and telephone lines
  18. Signals and interlockers
  19. Power plants
  20. Power transmission systems
  21. Miscellaneous structures
  22. Sand and gravel pits and quarries
  23. Roadway machines and tools

III. Equipment
  51. Locomotives
  52. Freight cars
  53. Passenger-train cars
  54. Floating equipment
  55. Work equipment
  56. Motor vehicles
  57. Shop machinery
  58. Power plant machinery

IV. General
  71. Corporate

V. Investment suspense
  81. Unadjusted investments

The number of primary accounts is reduced to 33. General account IV, entitled, "General expenditures" in the preceding draft of October 19, 1926, and there consisting of 9 primary accounts, is entitled in this most recent draft, "General," and consists of but one primary account, 71, "Corporate," to include all corporate organization expenses, consisting of charter costs, promoters' fees, costs incident to capital stock, expenses of reorganization committees, pay and expenses of executives, general officers and general office clerks, law services incident to organization, taxes, and stationery and printing.

General account V, "Investment Suspense," reduced to two primary accounts in the October, 1926, draft, is further reduced to one primary account, 81, "Unadjusted investments," intended to show the amount of a carrier's investment in carrier property in excess of that shown in the other accounts of this classification. All proposed changes in the account must be submitted to the Commission for its approval and no adjustments made except upon authority of the Commission. The cost of road purchased may be temporarily carried in this account until distributed to the primary accounts under general accounts I, II, and III.

Under "General Instructions" the general rules for accounting both for the acquisition and retirement of carrier property appear in one instruction, 6, "Property changes"; and the following instructions which appeared in the preceding drafts are eliminated: "Grading grounds and buildings," "Property retired and replaced," "Property retired and not replaced," "Equipment retired," "Land retired," and "Expenses in connection with property changes."

The proposed instruction to govern property changes is as follows:

6. Property Changes

(a) To the accounts of this classification shall be charged the cost of all carrier property acquired, including property purchased, property constructed by or for the carrier (including property replacing property retired), improvements to the existing property, and all property transferred from non-carrier to carrier use.

(b) To these accounts shall be credited, at the time of retirement, the ledger value of all carrier property retired.

The accounting for property retired shall be as follows:

(1) Fixed improvements and equipment: Concurrently with the retirement of the property (the cost of which is chargeable to the depreciable accounts of this classification) the ledger value, plus the cost of dismantling (including the cost of removing the foundations and filling excavations of buildings removed), and recovering the salvage less the value of the salvage (see instruction 2-m) and insurance recovered if any, shall be appropriately charged to account 776, "Accrued depreciation—Road," or account 777, "Accrued depreciation—Equipment." The value of the salvage recovered (see instruction 2-m) by the carrier shall be charged to account 717, "Material and supplies," or elsewhere according to the purpose for which the material is used.

(2) Property changes made by the lessee on leased property which, under the terms of the lease, are not borne or assumed by the lessor, shall be accounted for by the lessee in account 702, "Leased railway property."

(3) In case retired fixed improvements or equipment are held without dismantling, their salvage value shall be included, as may be appropriate, in account 705, "Miscellaneous physical property," or account 731, "Other unadjusted debits."

(4) Land: The ledger value (estimated if not known) of land retired, together with the proportionate cost of public improvements pertaining to the retired land, shall be credited to these accounts. If the land be sold, the difference between the ledger value, estimated if not known (including the proportionate cost of assessments for public improvements), and the sale price of the land, shall be debited to account 614, "Loss on retired road and equipment," or credited to account 603, "Profit on road and equipment sold," as may be appropriate. If the land be retained by the carrier, the aforesaid ledger value and proportionate cost of assessments shall be charged to account 705, "Miscellaneous physical property."

(5) Grading and tracklaying and surfacing: Concurrently with the retirement of tracks the amounts included in account 3, "Grading," and 10, "Tracklaying and surfacing," with respect to the retired property, shall be credited thereto. These amounts (less salvage if any) shall be charged to account 202, "Roadway and track repairs," except that if the tracks are not replaced with property of like purpose, the charge shall be to account 614, "Loss on retired road and equipment."

(c) For reasons of practicability and to avoid undue refinement in accounting, the cost of replacing in kind parts of fixed improvements (other than tracks) and equipment shall be charged to Operating Expenses.

Note: The provisions of the foregoing paragraph are not applicable to the replacement of parts if the new parts are of superior or inferior capacity or durability as compared with the

parts retired, nor shall it apply to the replacement of longitudinal sections of continuous structures, such as long trestles, fences, snowsheds, pole line, wire lines, etc. Such replacements shall be accounted for under the provisions of instruction 6-a and 6-b except that when the cost of labor applying the new part in replacement is substantially the same as the present cost of labor to apply the part retired, the cost of labor applying the new part and removing the part retired shall be charged to Operating Expenses.

(d) If the cost of repairs to any unit or fixed improvements or equipment in any instance exceeds 70 per cent of the cost new at current prices, it shall be accounted for as retired from service in accordance with instruction 6-b. The cost of the renewed unit shall be charged to the appropriate road and equipment account. This cost shall include the appraised value on the basis of current prices in place for the second-hand parts retained in the rebuilt unit without disassembling and replacement (due allowance being made for the second-hand condition thereof), plus the cost of material used and labor expended in the renewal thereof, but shall not include the cost of dismantling the old unit, the accounting for which is indicated in instrution 6-b-1.

The definition of "Ledger Value" is given as the value at which the property is carried in the property investment account; and it is further provided that in determining the ledger value of property retired from service when it is impracticable because of the relatively large number and small size of units of any kind to determine the specific ledger value thereof, estimated average prices may be used. The units referred to are such as rail, ties, tie plates, track spikes, track bolts or fence posts. By "property retired" is meant property permanently withdrawn from transportation service.

The instruction (No. 7) regarding "Cost of construction" is amplified to include rules concerning taxes and interest during construction, as follows:

(j) Taxes on carrier physical property belonging to the carrier assessed during construction and before the facilities are used for transportation service shall be included in the accounts appropriate for the property so taxed.

(k) Interest During Construction includes the amounts of interest incurred in the acquisition of carrier property. Such interest shall be charged to the accounts appropriate for the cost of the property in connection with the acquirement of which the interest is incurred. The interest includible in these accounts under this instruction is:

(1) Interest on bonds, notes and other evidence of indebtedness sold, and upon any interest-bearing debt incurred for the acquisition of carrier property. It includes the interest accruing on the part of the debt representing the cost of property acquired (less interest, if any, allowed by depositaries on unexpended balances) after such funds become available for use and before the receipt or the completion or coming into transportation service of the property so acquired.

There shall be deducted from such interest charges a proportion of premium on securities sold. The amount of premium thus deductible shall be determined by the ratio which the period between the date the proceeds from

the securities issued become available and the receipt, completion, or coming into service of the property bears to the entire life of the securities issued. Interest on bonds, notes or other evidences of indebtedness accruing before the proceeds from the sale of the securities become available for use shall not be included in these accounts nor shall there be included any interest accruing after the property with respect to which the proceeds are expended is received or becomes available for use in connection with transportation servcie. For definition of securities actually issued, see note B to account 755.

(2) The proportion of discount and expense on funded debt issued for the acquisition or construction of carrier property. The amount of discount and expense thus chargeable shall be determined by the ratio which the period between the date the proceeds from the securities issued become available and the receipt, completion, or coming into service of the property bears to the entire life of the securities issued. If any securities which have been issued or assumed by the carrier are sold or exchanged by or for the carrier for a consideration the actual money value of which at the time of such sale or exchange is less than the value of the securities at par and the accrued interest thereon, if any, the difference between the money value of the consideration received and the par value of the securities plus the accrued interest, if any, shall be deemed a discount. In no case except as provided in this paragraph shall discounts be included in these accounts.

(3) Reasonable charges for interest during the construction period before the receipt, completion or coming into transportation service of the property acquired, on the carrier's own funds expended for construction purposes, though mandatory as to important projects, does not apply to property changes, the cost of which is less than $1,000, nor to projects which are under construction for short periods only. Interest on the carrier's own funds charged to investment under the provision of this instruction, including the funds secured from sale of capital stock, shall be credited to account 523.

(4) When the work upon an important construction project is suspended for a period of one year or more the facts with respect to each case shall be submitted to the Commission for decision as to whether interest shall be charged to investment during the period of suspension. In case construction work on a project is definitely abandoned, no further interest charges shall be made.

Regarding adjustments for converted property, it is proposed that if the expense of physical conversion does not exceed $100 the ledger value of the unit shall be credited to the account in which carried and charged to the account appropriate for the use to which the property is converted; and the amount included in the accrued depreciation account for the converted unit shall be correspondingly transferred. If substantial physical changes are made in the unit because of conversion, the unit shall be retired in accordance with the rule governing "Property Changes."

The instruction in the preceding drafts covering "Rehabilitation of road and equipment purchased," is eliminated on the ground that under

the provisions of the depreciation order there is no requirement for this instruction. The proposed instruction (No. 12) governing "Railroad Purchased" is as follows:

The accounting for a railroad purchased shall be as follows:

(a) If the consideration paid or payable is other than cash, the current value thereof shall be determined on a current cash basis.

(b) The net purchase price of carrier property acquired shall be reckoned by adding to the cash value of the consideration determined as above the liabilities assumed (appraised on a current cash basis) and from this sum shall be deducted the appraised value of miscellaneous physical property, of securities, and of other assets (except carried property) acquired.

(c) The original cost of carrier property acquired includible in these accounts shall be ascertained:

(1) For property chargeable to account 1 on the basis of the actual cost of the land when first acquired for carrier use. In this cost there shall be included fair allowances to cover expenditures made by prior owners chargeable by them to accounts 2 and 3. The allowance for assessments for public improvements shall be limited to improvements made for the benefit of land actually acquired by the carrier, and allowances for crossings shall be limited to crossings still in existence.

(2) For property chargeable to general accounts II and III on the basis of finding 8, depreciation charges No. 15100.

(d) If the net purchase price of the carrier property acquired equals the original cost (determined in accordance with paragraph (c) of this instruction), minus the past accrued depreciation, the original cost of the property shall be included in these accounts and the past accrued depreciation shall be credited to the appropriate accrued depreciation reserve accounts.

(e) If the net purchase price of the carrier property acquired exceeds the original cost (determined in accordance with paragraph (c) of this instruction), minus the past accrued depreciation, such excess cost shall be charged to account 81, "Unadjusted investments," the original cost of the property acquired shall be charged to the accounts of this classification, and the past accrued depreciation shall be credited to the appropriate accrued depreciation reserve accounts.

(f) If the net purchase price of the carrier property acquired is less than the original cost (determined in accordance with paragraph (c) of this instruction), minus the past accrued depreciation, the original cost and the amount of past accrued depreciation shall be proportionately reduced to absorb this difference. The adjusted original cost thus determined shall be included in the appropriate accounts of this classification and the adjusted allowance for past accrued depreciation shall be credited to the appropriate accrued depreciation reserve accounts.

General instruction 3, "Accounts for investment in road and equipment," is as follows:

(a) These accounts are designed to show investment of the carrier in carrier property.

(b) For accounting purposes, the classification of property between carrier and noncarrier shall be consistent with the carrier's classification for valuation purposes.

(c) The accounts for each month shall be recorded currently.

(d) The carrier's accounts shall be so maintained that, at the close of any month, statements may be prepared showing:

(1) Amounts unaudited at the close of the month for projects completed on or before the last day of the month.

(2) Amounts audited and included in the accounts for the month or prior thereto for projects uncompleted at the close of the month.

(e) For accounting purposes the accounts of this classification are of two general classes:

(1) Depreciable accounts

4. Tunnels and subways
5. Bridges
6. Ties
7. Rails
8. Other track material
9. Ballast
11. Fences, snowsheds, crossings and signs
12. Station and office buildings
13. Roadway buildings
14. Fuel and water stations
15. Equipment shops
16. Wharves
17. Telegraph and telephone lines
18. Signals and interlockers
19. Power plants
20. Power transmission systems
21. Miscellaneous structures
23. Roadway machines and tools
51. Locomotives
52. Freight cars
53. Passenger-train cars
54. Floating equipment
55. Work equipment
56. Motor vehicles
57. Shop machinery
58. Power plant machinery

(2) Non-depreciable accounts

1. Land
2. Public improvements
3. Grading
10. Tracklaying and surfacing
22. Sand and gravel pits and quarries
71. Corporate
81. Unadjusted investments

The text of the primary accounts for Ties, Rails, Other track material, and Ballast is changed to include the cost of these elements of tracks which are directly used for transportation purposes, this being in accordance with the requirements of the depreciation order. It is proposed that the ledger value of all ties, rails, and other track material removed from tracks shall be accounted for as retired; and when ballast is applied in renewals, a quantity of ballast equal to that applied shall be reckoned as

retired and its ledger value considered its service value. To correspond with these changes in the road and equipment classification, the operating expense accounts "Ties," "Rails," "Other track material," and "Ballast" are eliminated entirely from that classification.

A new account, 22, Sand and gravel pits and quarries, is added in the last two drafts to include the value of sand in sand pits, gravel in gravel pits, and rock in quarries, and cost of improvements therein, when the products of the pits or quarries are to be used for construction or maintenance. There shall be credited to this account, monthly, and charged to the appropriate clearing account, provided in accordance with instruction 213 (classification of operating expenses), the monthly depletion of investment in this account. The depletion charges shall be reckoned on the ratio of the monthly production to the total estimated production of the pit or quarry.

Regarding general account IV, "General," it is proposed that with the exception of expenses of a general character, as outlined for account 71 (and previously mentioned), other expenses formerly included in this general account shall be distributed to the various primary accounts for the property in connection with which the expenditures occurred.

Land Account

The proposed revisions of the land account in the tentative draft of March, 1926, have previously been mentioned. Land was there made a general account, with one primary account, "Land for common carrier purposes." In subsequent drafts, a second primary account has been added, "Public improvements," which is, in substance, present account 39, "Assessments for public improvements." The most recent draft, that of April, 1927, contains the two accounts under land. The general account is there entitled, I, "Land for transportation service;" and the primary accounts are, respectively, 1, "Land," and 2, "Public improvements."

Account 1 has been amended in minor respects since the earlier draft. In the April, 1927, draft, for example, there are omitted from the detailed list of items chargeable to the account, (a) damages for non-fulfillment of conditions of purchase of right-of-way, (b) damages to property or interests of others arising from proximity of the railroad, (c) directly assignable expenses in procuring passage of ordinances granting right to occupy public property with tracks, (d) fees assessed by public authority for permits to build and maintain permanent tracks, either on property of the carrier or on public property, and (e) rent of land when a part of consideration for purchase. New items are inserted covering (a) lump sum payments for right to use in perpetuity or for a period of years public property for transportation service (such amounts paid for right to use for a period of years only, to be amortized through income account 532, "Railway tax accruals"); and (b) permanent rights to erect and maintain snow and sand fences.

There are omitted from the later draft the provisions (previously mentioned) in the March, 1926, draft to the effect that rent paid (less

rent received from subtenants, if any), pending actual purchase, for land rented primarily for addition and betterment projects and later purchased for the projects, shall be included in this account; that amounts received for easements or rights to use the right-of-way for telegraph, telephone, or pipe lines, or for permanent roadways and footpaths, be credited to this account to an extent not exceeding the cost of the property involved, the excess, if any, to go to profit and loss account; and that cost of land purchased along lines held under long-term lease or lines of controlled companies, and used in transportation service, be included.

The proposed rule covering sale of minerals is to the effect that proceeds therefrom of minerals "known to be in the land when purchased and considered in the purchase price thereof," shall be credited to this account. The net proceeds from sale of minerals or timber in excess of the amount considered therefor in the purchase price of the land shall be credited to profit and loss account, "Miscellaneous credits."

Account 2, Public improvements, is intended to include amounts assessed on carrier property by governmental authority to cover the cost of constructing public improvements, when such assessments are made against property within defined areas of taxing districts, and also the cost borne by the carrier of public improvements constructed by it under governmental requirements. Items of public improvements include curbing streets and highways, drainage systems, flood protection, grading streets and highways, irrigation systems, levees, paving (except at crossings), sewer systems, sidewalks, street lighting systems, and water works. The costs borne by a carrier of joint projects are not to be considered assessments for public improvements. Any portion of the cost of public improvements included in the general tax levy for a regular taxing district would go to the appropriate tax account. If an assessment is to be paid in installments, the full amount shall be charged to this account when the assessment is levied and the deferred payments included in balance-sheet account "Other deferred liabilities." Interest on installments which are deferred without option of the carrier are to be included as a part of the assessments, all other interest on assessments to go to income debit account "Interest on unfunded debt." Penalties for failure to pay assessments within allotted time shall be charged to income debit account "Miscellaneous income charges." The cost of maintaining public improvements shall be charged to operating expenses, as at present. Assessments on non-carrier property for constructing public improvements go to balance-sheet accounts for miscellaneous physical property.

Recommendations by Carriers' Accounting Committee

In considering the tentative draft of April, 1927, submitted by the Bureau of Accounts, the Committee on General Accounts of the Accounting Officers' Association expressed the opinion in regard to the proposed rules governing property changes that the loss on all carrier property retired should be uniformly charged to operating expenses; and recommends a change in proposed instruction 6, paragraph b-5, accordingly. (See above.)

Regarding paragraph (c) under general instructions for property changes (see above), the committee recommends the elimination of the reference to replacing longitudinal sections of continuous structures such as long trestles, fences, snowsheds, pole lines, etc., for the reason that it is impossible to determine definitely what constitutes the longitudinal section of a continuous structure.

Regarding the provision that if the cost of repairs to any unit of property exceeds 70 per cent of the cost new at current prices it shall be accounted for as retired from service, the committee recommends 75 per cent in place of 70 per cent, believing that if the cost of repairs to any unit equals 75 per cent of its cost new at current prices the policy of the management would be replacement.

Regarding the rule that a fair allowance representing the expense to the carrier of transportation in transportation service trains over the carrier's own line in connection with construction work shall be included as a cost of construction, amounts thus charged being credited to operating expense, the committee again recommends the elimination of this rule on the ground that such charges cannot be definitely determined and the allowances so used are merely arbitrary estimates.

Regarding paragraph k-2 under "Cost of construction" (see above), providing that a proportion of discount and expense on funded debt issued for the acquisition or construction of carrier property be included in the investment accounts on the basis of the ratio of the period prior to the property coming into service and the period representing the life of the securities issued, the carriers' committee considers that expenses of that nature, as distinct from discount, should be included in operating expenses. The committee is also of the opinion that the minimum sum upon which interest should be reckoned in the case of property changes, or projects under construction for short periods only, should be not less than $10,000.

Regarding general account IV, primary account 71, "Corporate," the accounting committee suggests the elimination of this entire general, and primary, account, being of the opinion that all expenditures for road and equipment should be included as direct charges to the cost of the project and structures, and the primary accounts affected, or, if direct charges cannot be made, the expenses should be equitably apportioned.

With reference to crossings, the committee recommends that, for the purpose of accounting, all crossings constructed at the joint expense of a carrier and others be considered as joint projects, the amount to be included in the investment accounts to be the construction cost of the structures acquired by the carrier regardless of the terms of settlement for the joint project; and that the cost of property acquired in the construction of joint projects, in excess of the cost to the carrier, be considered a donation and credited to profit and loss.

Regarding a railroad purchased, it is recommended by the accounting committee that the net purchase price of the carrier property acquired

be recorded by primary accounts of the investment classification on the following basis:

1. General account I—
   Appraised current value.
2. General accounts II and III—
   Estimated cost to reproduce at current prices less suitable allowance for present condition.
3. General account IV—
   The difference between the total net purchase price and the aggregate amounts charged to accounts I, II, III.

The committee also considers the proposed instructions, covering a railroad purchased, that carrier land when subsequently acquired by other carriers shall be accounted for at "actual cost of the land when first acquired for carrier use"; that if the net purchase price of property acquired equals the original cost, minus the past accrued depreciation, the original cost shall be included in these accounts and the past accrued depreciation be credited to the appropriate depreciation reserve account; the paragraph requiring the purchasing carrier to account for the amount paid in excess of the original cost of the property acquired to "Unadjusted investments"; and the paragraph requiring the purchasing carrier to "scale down" depreciable accounts if it has been able to acquire physical property at cost less than original cost; are all objectionable, if not impossible.

In submitting these recommendations to the Commission's representatives, the Committee on General Accounts of the Accounting Officers' Association retains the position expressed in its proposed classification of investment in road and equipment, recommended in May, 1926, based upon the principle of three accounts, namely, I, "Road," II, "Equipment," and III, "Investment Suspense"; and suggests the foregoing changes in the tentative classification proposed by the Bureau of Accounts only in the event the Commission retains the system of primary accounts for the investment classification. In the latter event, it is further recommended that the following accounts be combined:

Account 3—Grading
" 6—Ties
" 7—Rails
" 8—Other track material
" 9—Ballast
" 10—Tracklaying and surfacing,

these accounts to be consolidated into one account, "Roadway and track."

The accounting rule for ballast, in the proposed classification, is that the ballast account include the cost of the ballast material and also the cost of work-train service and unloading; the cost of placing ballast in tracks not previously ballasted being charged to tracklaying and surfacing, account 10. The carriers' committee recommends that the cost of labor unloading and distributing at point of use, including the cost of work-train service in connection with the distribution of the ballast, be charged to tracklaying and surfacing. This would provide the same treatment for labor handling ballast as that accorded ties, rails, and other

track material. The cost of preparing tracks, which have been used in operation, for the reception of initial ballast, will be charged, under the proposed classification, to operating expenses. The application of ballast in tracks previously ballasted will be charged to operating expenses, as at present.

The cost of installing additional elements of track construction, after the commencement of commercial operations, such as the application of ballast or tie plates to tracks previously ballasted or tie-plated, is to be charged to operating expenses in the proposed classification.

Regarding proposed account 81, "Unadjusted Investments," it is recommended that this account include not only the excess but recess, if any; and that the account be restated to conform to this principle.

PROPOSED REVISIONS OF CLASSIFICATION OF OPERATING REVENUES

The Bureau of Accounts submitted a proposed revision of the classification of operating revenues in 1925. It was jointly considered with the representatives of the Accounting Officers' Association, redrafted, and circulated again in June, 1926. (Printed in Bulletin No. 111, Railway Accounting Officers' Association.) It was again redrafted, with some changes, and reprinted in October, 1926. (Bulletin No. 112, Railway Accounting Officers' Association.) A further draft was issued under date of April 26, 1927, without substantial change from the preceding draft. (Bulletin No. 113, Railway Accounting Officers' Association.)

The several changes proposed include a provision that the carriers shall file with the Commission comprehensive statements of their plans for accruing unaudited revenues and for adjusting accrual estimates to actual revenues earned; and make no change in practice without submitting the proposed revisions to the Commission. The purpose of the provision is to inform the Commission of the practices of the carriers in this matter and to permit correction of improper practices. The carriers' accounting committee objects to it for the reason that such requirements will restrict initiative and experiments.

Regarding estimates for unaudited items affecting operating revenues, it is proposed that if, during the interval between the date of inclusion of the item in the accounts and the date on which it is audited, a substantial difference is determined between the initial estimate and the actual amount of the item, appropriate adjustment shall be made in the current accounts to cover such difference; the carrier to preserve a record of the information upon which the supplemental estimate is based.

The proposed classification includes a new account for revenue from heating and refrigerating service, in view of the greatly increased revenues from this source. The carriers' representatives recommend its elimination because it seeks to distinguish between "stated refrigeration" and miscellaneous icing charges, the former to be credited to revenue and the latter to operating expense, whereas there is no profit in either; and because it would penalize carriers in states where taxes are assessed on gross operating revenues, since there is no profit from this incidental refrigeration

service. Should the Commission retain the proposed account in the revised classification, it is recommended that the cost of ice be deducted from the credits to the account.

The proposed classification provides that no amount representing rent of property shall be included in the revenue accounts.

Regarding joint facility accounts, joint train service would be considered a joint facility operation, each carrier involved to include in the appropriate revenue accounts (other than joint facility accounts) the revenues pertaining to the trains operated by it, the difference between the revenue thus credited by each carrier and its proportion of the total pooled revenue to be adjusted through the joint-facility revenue accounts.

No amounts may be included in revenue account, under the proposed classification, representing transportation over a company's lines of material and supplies for its own use, unless such charges are included in the price thereof and borne by the shipper.

The accounts "Dining and Buffet" and "Hotel and Restaurant," upon recommendation of the carriers' representatives, are made net accounts, representing the difference between receipts from the service and the cost of consumable and salable supplies.

Other minor changes are proposed in the accounts. Under general account III, Incidental, the present accounts 134, Parcel room, 135, Storage-freight, and 136, Storage-baggage, are abolished, these credits to be absorbed in the account, "Station, Train, and Boat"; and account 142, "Rents of buildings and other property," is abolished in accordance with the proposed rule not to credit in the revenue accounts any amounts representing rent of property. A new account, 140, "Other Service," is added, to include revenue from miscellaneous operations such as coal-storage, cold-storage, cotton compress, wood preserving, and ice-supply; in addition to the new account "Heating and refrigeration" previously mentioned. Thus the number of primary accounts is reduced from 39 to 37.

PROPOSED REVISIONS OF CLASSIFICATION OF OPERATING EXPENSES

A tentative revision of the accounting rules for operating expenses was the first of the several tentative classifications submitted by the Bureau of Accounts for discussion and suggestions. It was circulated in November, 1923. The principal features of the proposed revision have been previously mentioned in the first part of this report.

DRAFT OF OCTOBER, 1926

A revised draft was given general circulation in October, 1926. (Printed in Bulletin No. 112, Railway Accounting Officers' Association.) The suggested arrangement and number of general and primary accounts were as follows:

General Accounts

I. Maintenance of way and structures.
II. Maintenance of equipment.
III. Transportation—Rail line.
IV. Transportation—Water line.
V. Miscellaneous Operations.
VI. Traffic.
VII. General.
VIII. Transportation for investment—Cr.

Primary Accounts

I. Maintenance of Way and Structures—

201. Supervision.
202. Roadway and track.
203. Tunnels.
204. Bridges.
205. Ties.
206. Rails.
207. Other track material.
208. Ballast.
209. Fences, snowsheds, crossings and signs.
210. Station and office buildings.
211. Roadway buildings.
212. Fuel and water stations.
213. Equipment shops.
214. Wharves.
215. Telegraph and telephone lines.
216. Signals and interlockers.
217. Power plants.
218. Power transmission systems.
219. Miscellaneous structures.
220. Roadway machines and tools.
221. Roadway supplies.
222. Removing snow, ice and sand.
223. Public improvements.
224. Injuries to persons.
225. Stationery and printing.
226. Other expenses.
227. Maintaining joint tracks, yards, and other facilities—Dr
228. Maintaining joint tracks, yards, and other facilities—Cr
229. Insurance.
230. Fixed improvements—Depreciation.
231. Fixed improvements—Retirements.
232. Equalization—Way and structures.
233. Amortization—Way and structures.

II. Maintenance of Equipment—

301. Supervision.
302. Shop machinery.
303. Power plant machinery.
304. Locomotives—Repairs.
305. Freight cars—Repairs.
306. Passenger-train cars—Repairs.
307. Floating equipment—Repairs.
308. Work equipment—Repairs.
309. Miscellaneous equipment—Repairs.
310. Injuries to persons.
311. Stationery and printing.

II. Maintenance of Equipment—Continued

312. Other expenses.
313. Maintaining joint equipment—Dr.
314. Maintaining joint equipment—Cr.
315. Insurance.
316. Equipment—Depreciation.
317. Equipment—Retirements.
318. Equalization—Equipment.
319. Amortization—Equipment.

III. Transportation—Rail Line—

371. Supervision.
372. Dispatching trains.
373. Station employees.
374. Weighing, inspection, and demurrage bureaus
375. Coal and ore wharves.
376. Station supplies and expenses.
377. Yardmasters and yard clerks.
378. Yard conductors and brakemen.
379. Yard switch tenders.
380. Yard enginemen.
381. Yard motormen.
382. Fuel for yard locomotives.
383. Yard switching power produced.
384. Yard switching power purchased.
385. Water for yard locomotives.
386. Lubricants for yard locomotives.
387. Other supplies for yard locomotives.
388. Enginehouse expenses—Yard.
389. Yard supplies and expenses.
390. Train enginemen.
391. Train motormen.
392. Fuel for train locomotives.
393. Train power produced.
394. Train power purchased.
395. Water for train locomotives.
396. Lubricants for train locomotives.
397. Other supplies for train locomotives.
398. Enginehouse expenses—Train.
399. Trainmen.
400. Train supplies and expenses.
401. Operating sleeping cars.
402. Signal and interlocker operation.
403. Crossing protection.
404. Drawbridge operation.
405. Telegraph and telephone operation.
406. Water transfer operation.
407. Stationery and printing.
408. Other expenses.
409. Operating joint facilities—Dr.
410. Operating joint facilities—Cr.
411. Clearing wrecks.
412. Damage to property.
413. Damage to live stock on right-of-way.
414. Loss and damage—Freight.
415. Loss and damage—Baggage.
416. Injuries to persons.
417. Insurance.
418. Equalization—Transportation.

IV. Transportation—Water Line—
- 431. Operation of vessels.
- 432. Operation of terminals.
- 433. Incidental.
- 434. Insurance.

V. Miscellaneous Operations—
- 441. Dining and buffet service.
- 442. Hotels and restaurants.
- 443. Other miscellaneous operations.

VI. Traffic—
- 451. Supervision.
- 452. Solicitation.
- 453. Development.
- 454. Stationery and printing.
- 455. Other expenses.
- 456. Insurance.
- 457. Equalization—Traffic.

VII. General—
- 461. General officers.
- 462. General office clerks and attendants.
- 463. General office supplies and expenses.
- 464. Law expenses.
- 465. Pensions and relief.
- 466. Stationery and printing.
- 467. Valuation expenses.
- 468. Other expenses.
- 469. General joint facilities—Dr.
- 470. General joint facilities—Cr.
- 471. Insurance.

VIII. Transportation for Investment—Cr.

The formerly proposed requirement that the primary accounts be subdivided as between (a) labor, (b) material, and (c) miscellaneous items, was abandoned. Similarly, the proposed new accounts "Work Train Service," "Shop Expenses," "Preparing Motive Power," "Preparing Cars," and "Transfer and Delivery Service," were dropped. "Roadway Maintenance" and "Tracklaying and Surfacing," Accounts 202 and 220 in the present classification, are here combined into one account, "Roadway and Track."

Depreciation Accounts

One primary account was provided, in the proposed classification, under general account I, Maintenance of Way and Structures, to cover charges for depreciation of fixed improvements. A similar account was provided under general account II, Equipment, to include charges for depreciation of equipment. The amounts thus charged were made creditable to account 776, "Accrued depreciation—Road," or account 777, "Accrued depreciation—Equipment," in the balance sheet account, to meet or reduce amounts otherwise chargeable as might be appropriate to Operating Expenses or to Profit and Loss to cover the service value of property retired. Amounts charged to operating expenses or other accounts to cover depreciation of fixed improvements or equipment under

lease, when the investment therein is not included in the property investment account, were to be included in balance sheet account "Other Unadjusted Credits."

Property Requirements

One primary account was provided under general account I, Maintenance of Way and Structures, to include the service value, of fixed improvements retired and replaced, in excess of the amounts previously provided for, with respect to retired property, in balance sheet account 776, "Accrued depreciation—Road"; a similar account being provided under general account II, Equipment, in which to include service value of equipment retired in excess of amounts previously provided for, with respect to the retired property, in account 777, "Accrued depreciation—Equipment."

> If so authorized by the Commission, the carrier may charge to Profit and Loss any extraordinarily large item representing *the loss in* property retired and replaced, instead of charging such item to Operating Expenses. With its application for such accounting the carrier shall file with the Commission a statement of the cost, with a description of the property so retired, and give the reasons which, in its judgment, indicate the propriety of charging the *loss in the* property to Profit and Loss. (Proposed Instruction 223 b, concerning distribution of charges for property retired and replaced.)

Equalization of Expenses

Equalization accounts, eliminated in the earlier revision, were restored with the following instructions:

> If the carrier adopts at the beginning of the calendar year or during the year a budget or determines in advance the amount to be expended chargeable to one or more of the primary accounts under general accounts I, II, III or VI, for the purpose of equalizing the charges thereto, it shall file with the Commission as soon as its program is adopted a statement showing the amount authorized for each general account for each month of the year or for the remaining months of the year according to the plan adopted. It shall file a supplementary statement furnishing similar information for any modification later made in the original plan.
>
> If the total accrued liabilities charged to the primary accounts in any general account in any month are less than the amounts authorized, the difference shall be charged to the appropriate equalization account. If the total charge is more than the monthly proportion of the authorization the difference shall be credited to the appropriate equalization account.
>
> Amounts charged or credited to Operating Expenses for equalization purposes shall be credited or charged to account 775, "Equalization reserves."
>
> All equalization reserve accounts shall be cleared at the close of the calendar year through the accounts used in creating the reserves.

Fixed Improvements Retired and Replaced

The ledger value of fixed improvements retired and replaced with property of like purpose, together with the cost of dismantling and recov-

ering the salvage of the property retired (less the value of the salvage after recovery and the accrued depreciation) was to be included in account 231, "Fixed Improvements—Retirements." Where a longitudinal section of a continuous structure, such as long trestle, fence, snowshed, pole line, wire line, etc., is renewed in its entirety, with or without betterment, the accounting was put on the basis of property retired and replaced.

Other Changes in Instructions

Among other changes proposed in the "Instructions" governing the operating expense accounts are the following:

> No amount representing rent of property shall be included in these accounts. (Proposed Instruction 203 b.)
>
> The accounting for Operating Expenses shall, as nearly as practicable, be coincident with the transactions which create them. If for the purpose of meeting this requirement the carrier accounts for loss and damage, injuries to persons or other expense items upon an accrual basis it shall file with the Commission a comprehensive statement indicating the particulars of its plan of accruals, and no change shall be made in such accounting before the particulars of its revised plan have been submitted to the Commission. The cost of repairs shall, as nearly as practicable, be included in the primary accounts for the month in which the repairs are actually made. (Proposed Instruction 203 d.)
>
> Maintenance expenses shall include the expense "of maintaining or protecting railroad traffic during the progress of construction work." (208)
>
> Clearing accounts shall be established as at present, for shop expenses, material store expenses, and stationery store expenses, the amounts to be subsequently apportioned as at present; the instruction being added, however, that the balance in the shop expense account must be cleared each calendar year; the balances in each of the clearing accounts to be included in balance sheet account "Other unadjusted debits."
>
> To the insurance accounts shall be credited amounts recovered from insurance companies, or released from insurance reserves, on account of losses sustained which are covered by insurance, when the premiums are chargeable and have been charged thereto. (225 b.)

Regarding sand and gravel pits and quarries, it is proposed that when a pit or quarry is acquired for operations to extend over a long period, there shall be charged to proposed R. and E. account 22, "Sand and gravel pits and quarries," the estimated cost of the sand, gravel, or rock, the amount paid property owners for the right to remove such materials, and all other costs incident to sinking test holes, stripping, installing tracks, buildings, machinery, etc., preparatory to operating the pit or quarry; and that clearing accounts shall be opened under operating expenses to which shall be charged: (a) The depletion in the investment account 22, the depletion charges to be reckoned upon the basis of the ratio of the output in the month of the estimated total material in the pit or quarry; (b) the cost of labor and switching service expended in producing, quarrying and loading material, and the cost of repairs to the machinery, tracks, and buildings in the pit or quarry; and (c) the cost of explosives, additional small tools and miscellaneous expenses. Each such

account shall be cleared each month by crediting thereto the cost of the material produced. This credit entry shall show the quantity of material produced during the month and the total cost of production. The amounts thus credited to this account shall concurrently be charged, according to the purpose for which the material is used, to the appropriate road and equipment or operating expense account or to account 717, "Material and supplies." If any portion of the product from the pit or quarry is sold, the proceeds from the sale shall be accounted for through account 717, except that the profit over the cost of production shall be included in account 141, "Miscellaneous." (Instruction 213.)

With reference to overhead expenses charged to others, it was proposed that amounts included in bills collectible (ordinarily reckoned upon a percentage basis) to cover undistributed expenses should be credited as follows: (1) Supervision and accounting, to appropriate supervision account; (2) for purchasing and handling material, to clearing account "Material store expense"; and (3) overhead charges added to joint facility bills, to appropriate joint facility creditor accounts. (211.)

Ties, Rails, and Other Track Material

The account "Ties" (205) was modified to provide as follows:

This account shall include the cost of cross, switch, bridge, and other track ties used in repairing tracks for the movement or storage of locomotives and cars (including tracks in shops, fuel stations, supply yards, etc.) except that if either bridge, switch, or cross ties are substituted, one for the other, and the cost of the ties laid is in excess of the cost at current prices of the ties removed, the excess cost of the ties laid shall be included in account 6, "Ties," and not in this account, and if the cost of the ties laid is less than the cost, at current prices, of the ties removed, the difference between the cost of the ties laid and the cost, at current prices, of the ties removed shall be charged to this account and concurrently credited to account 6, "Ties."

To account 206, "Rails," it was proposed to charge the cost (less salvage) of rail used in repairing tracks, except that if rails of a heavier type are laid in substitution of rails of a lighter type removed, the cost of the increased weight would be charged to R. and E. account 7, "Rails"; and if rails of a lighter type are laid in substitution of heavier rails removed, the cost at current prices of the decrease in weight would be charged to this operating expense account and concurrently credited to R. and E. account 7. Similar provision was made for accounting for other track material.

Valuation Expenses

In connection with valuation expenses, it is proposed that primary account 467, "Valuation Expenses," include only expenses incurred on account of the "primary" valuations, and that expenses in connection with perpetuation of records such as those compiled under Valuation Order No. 3 be charged to other appropriate primary accounts under General Account VII, General.

Transportation for Investment

General Account VIII, "Transportation for Investment—Cr.," is intended to include fair allowances representing the expense of transporting, on transportation trains, men and material for construction; amounts credited to this account to be concurrently charged to appropriate investment accounts.

Changes Recommended by Carriers' Representatives

The representatives of the Accounting Officers' Association recommended a number of changes in the proposed classification, draft of October, 1926. Among them are the following:

It was recommended that a general account under the caption "Miscellaneous" be provided to include primary accounts as follows:

(a) Retirements
- 1 Account 231—Fixed Improvements—Retirements,
- 2 Account 317 — Equipment — Retirements,

(b) Depreciation
- 1 Account 230—Fixed Improvements—Depreciation,
- Account 316 — Equipment — Depreciation,

(to remove from General Accounts I and II items commonly referred to as "Bookkeeping" items, leaving in these general accounts cash expenditures only);

(c) Valuation Expenses—Account 467

(d) Insurance—Accounts 229, 315, 417, 434, 456, 471 (consolidated into one account).

(e) Pensions and Relief—Account 465.

(f) Casualties
- 1 Injuries to persons—Accounts 224, 310 and 416;
- 2 Loss and Damaged Freight—Account 414;
- 3 Other damages—
  A consolidation of the following accounts: 412 Damage to Property; 413 Damage to Live Stock on Right-of-Way; and 415 Loss and Damage—Baggage.

(g) Material Store Expenses—
- 1. Material Store Expenses.
- 2. Stationery Store Expenses.

It was explained that expenditures incident to valuation, insurance and pensions and relief are not considered to be in the category of General Expenses, and should be removed from that group; that casualties of the character described are customarily unavoidable and it is desirable to assemble such expenditures under a miscellaneous group.

It was recommended that primary accounts be provided for:

(1) Work Train Expenses (under Maintenance of Way and Structures).

(2) Shop Expenses (under Maintenance of Equipment).

(3) Material Stores Expenses (under Miscellaneous Operations).

(4) Stationery Store Expenses (under Miscellaneous Operations).

The reasons stated for these recommendations were: (a) The necessity of allocating such charges to other primary accounts, and the complicated distribution incident thereto, would be eliminated; (b) the expense incident to such allocation would be avoided, and clerical help released for more important duties; (c) a total of the expenses would be immediately available and the responsible officers in possession of information not readily obtainable under the present classification; (d) the practice of charging expenses supervised by one department to other departments not having supervision over such expenses would be eliminated.

A consolidation of the following accounts was recommended:

(a) Account 373—Station Employees.
Account 374—Weighing, Inspection, and Demurrage Bureaus,
Account 375—Coal and Ore Wharves,
Account 376—Station Supplies and Expenses,

to bring together labor, supplies and incidental expenses due to the operation of stations.

(b) Account 378—Yard Conductors and Brakemen,
Account 379—Yard Switch Tenders,
Account 380—Yard Enginemen,
Account 381—Yard Motormen,

in order that all labor employed in transportation yards be included in one account.

(c) Account 382—Fuel for Yard Locomotives,
Account 383—Yard Switching Power Produced,
Account 384—Yard Switching Power Purchased,

in order that all elements of fuel and power for yard services be included in one account.

(d) Account 385—Water for Yard Locomotives,
Account 386—Lubricants for Yard Locomotives,
Account 387—Other Supplies for Yard Locomotives,
Account 389—Yard Supplies and Expenses,

to consolidate in one account all supplies (except fuel) for yard locomotives and incidental yard operating expenses.

(e) Account 388—Enginehouse Expense—Yard,
Account 398—Enginehouse Expenses—Train,

because enginehouse expense should be considered as a terminal operation; and the separation now being made between yard and road is not on an accurate basis, cannot be definitely determined, and produces misleading results.

(f) Account 390—Train Enginemen,
Account 391—Train Motormen,

in order that all train enginemen be included in one account.

(g) Account 392—Fuel for Train Locomotives,
Account 393—Train Power Produced,
Account 394—Train Power Purchased,

for the same reason expressed as to similar accounts in yard operation.

(h) Account 395—Water for Train Locomotives,
Account 396—Lubricants for Train Locomotives,
Account 397—Other Supplies for Train Locomotives,
Account 400—Train Supplies and Expenses,

in order that all supplies for trains (except locomotive fuel) be included in one account.

(i) Account 403—Crossing Protection,
Account 404—Drawbridge Operation.
(j) Account 412—Damage to Property,
Account 413—Damage to Live Stock on Right-of-Way,
Account 415—Loss and Damage—Baggage,

the latter three accounts to be consolidated under the title "Other Damages" for the reason that stock is "property" and charges due to loss and damage-baggage are small, as shown in the annual reports.

Regarding the practice of charging to suspense account property abandoned and chargeable to operating expense, it was recommended that provision be made for accruing, through charges to operating expenses, a part or all of such losses in anticipation of important retirements.

Regarding "Injuries to Persons," it was recommended that the interest paid in such claims be included in the same account as the principal sum.

Whereas the tentative classification proposed that repairs to locomotives engaged in work-train service be charged to "Work Equipment—Repairs," it was recommended that all repairs of locomotives be included in account 304, "Locomotives—Repairs," except that when locomotives are assigned to construction work the cost of repairs should be included in the cost of the project on which engaged. Regarding "Clearing Wrecks," it was suggested that the account be eliminated and the expenses ordinarily included therein be charged to primary account (proposed) Work Train Service and account 202, "Roadway and Track," as may be appropriate.

Regarding "Pensions and Relief," it was recommended that the carriers be permitted to charge to this account premiums paid to insurance companies for annuity policies or amounts credited to reserves or turned over to trustees to represent the carriers' provisions for pensions to employees currently retired. The Accounting Officers' Committee had previously explained to the Bureau of Accounts (letter, February 23, 1926) that many carriers are faced with a rapid rise in pension payments, and to continue on the basis of pensions paid would oblige the carriers in the near future to increase their pension payments, so that they would absorb a much larger proportion of the current payroll than they do now (unless, of course, there be a correspondingly large increase in the number of employees and the pay received by them). It was suggested that it is conservative business to have the affairs of the company in such shape that the balance sheet may reflect its ability to liquidate, as nearly as may be, at any given date. The Accounting Officers' Committee was advised by the Bureau of Accounts, in reply (letter, May 15, 1926), that

the recommendation does not meet with the Commission's approval because (1) it does not recognize the requirements of uniformity in accounting implied in section 20 of the Interstate Commerce Act, and (2) there is no evidence that any considerable number of carriers would adopt the option recommended, if approved by the Commission.

It was recommended by the carriers' committee that the account for valuation expenses include all expenses incurred by the carriers on account of Section 19a of the Interstate Commerce Act, and not divided, as proposed in the tentative classification, by charging valuation order No. 3 expenses elsewhere.

The Accounting Committee repeated its recommendation that the provisions requiring charges for transportation construction material over a carrier's own line, be eliminated, for the reason that such charges cannot be definitely determined and are merely arbitrary estimates.

DRAFT OF APRIL 26, 1927, TENTATIVE CLASSIFICATION OF OPERATING EXPENSES

The Bureau of Accounts, in April, 1927, submitted another draft of its tentative classification of Operating Expenses, revised to give effect therein to the Commission's depreciation order, No. 15100. (Printed in Bulletin 113, Railway Accounting Officers' Association.) A new instruction relating to depreciation accounts was inserted with the following provisions:

219. *Depreciation Accounts*

(a) One primary account has been provided under general account I, Maintenance of Way and Structures, and another under General Account II, Equipment, to include the charges for depreciation of carrier physical property.

(b) The rates used in accruing the depreciation charges shall be determined in accordance with the order contained in No. "15100, Depreciation Charges of Steam Railroad Companies," November 2, 1926, and any supplementary orders pertaining thereto.

(c) The amounts charged to these accounts shall concurrently be credited to account 776, "Accrued Depreciation—Road," or account 777, "Accrued Depreciation—Equipment," as may be appropriate, except that: If, under the terms of the lease, the service value of leased property when retired (amount chargeable to the accrued depreciation accounts under the provisions of Instruction 6-b-1) is borne by the lessor, the lessee shall include in these accounts and credit to the rent account (in which the rent of the leased property is included) the current depreciation charges on the leased property. Correspondingly, the lessor shall currently charge to the rent account (in which is included the rent from the leased property) and credit the appropriate accrued depreciation account the amount of these depreciation charges.

A new instruction, "Extraordinary Repairs—Cr.," was also included as follows:

220. *Extraordinary Repairs—Cr.*

One primary account has been provided under general account I, Maintenance of Way and Structures, and another under general

account II, Maintenance of Equipment, to cover credits on account of extraordinary repairs. (See instruction 209-b.) The amounts thus creditable to these accounts shall concurrently be charged to account 776, "Accrued depreciation—Road," or account 777, "Accrued depreciation—Equipment," as may be appropriate.

The instruction 209-b, above referred to, reads as follows:

(b) If the cost of repairs, in any instance, to a particular unit or property owned or leased by the carrier (except as provided in instruction 6-d) to carriers, Class I, exceeds 30 per cent of the cost new at current prices of the unit, and to carriers, Classes II and III, exceeds 15 per cent of the aforesaid cost of new property, the cost of repairs in excess of the aforesaid percentages shall be credited to the appropriate extraordinary repair creditor account and charged to the corresponding depreciation reserve account. This provision is not applicable when the cost of repairs in any instance does not exceed $100.00.

Previous instructions intended to govern "Fixed improvements retired and replaced," "Equipment retired," "Accounts for property retirements," and "Distribution of charges for property retired and replaced," were eliminated due to the depreciation order.

The Committee on General Accounts of the Accounting Officers' Association, after reviewing this latest draft, reported as follows regarding the new provision to govern "Extraordinary repairs" (see above):

The procedure suggested in the (Depreciation) Order for this item is based upon the theory that as heavy repairs tend to lengthen the service life, such repairs should be spread over the service life through depreciation charges instead of being charged when made to Operating Expenses. The result will be a "dead line" of charges to Operating Expenses through Depreciation regardless of the actual work done and the expenses therefore for maintenance will have no relation to the earnings. In a year of large earnings the government will take one-half of the profits under the recapture clause while in poor years the maintenance expense will not change and a possible deficit may result. In its report accompanying the Order the Commission states that without this method of accounting "reserves will be created that will serve no useful purpose." It is submitted this is a fallacy as the reserve from depreciation charges to take care of ultimate retirement of the property will not be affected by this rule but there will be added to the reserve a sum to take care of extraordinary repairs which will be idle until the repairs are made, leaving the "retirement" Depreciation Reserve intact. The accounts should exhibit the facts and if extraordinary repairs are made, the account should show it with a proper explanation. The principal difficulty of the Bureau of Accounts is the determination of what constitutes extraordinary repairs and a percentage of the cost has been suggested which appears to be pure speculation. In the case of freight cars, if the cost of the repair is in excess of, say, 30 per cent of the production cost of the car, such excess must be charged to Depreciation Reserve instead of to Operating Expenses. This same rule will apply to locomotives, passenger cars, work cars, stations, bridges and all other units of carrier property classified as depreciable. It is submitted that the Commission has confused extraordinary repairs with the ordinary classified repairs which normally

occur in cycles throughout the life of any unit of property. Railroads require certain standards of condition, which are maintained:

(a) Concurrently, through the medium of so-called "current" or "spot" repairs.

(b) Through the medium of general or classified repairs. Both are required in transportation service to maintain the standard condition specified. Extraordinary repairs should only be construed to comprehend repairs of unusual character, exceptionally costly, such as restoration or reconstruction occasioned by the elements, i. e., floods, hurricane, storms, etc.

The Accounting Officers' committee recommended, in the event the proposed provision concerning extraordinary repairs is finally included in the classification, that the "dead line" of charges to operating expenses be raised from the proposed 30 per cent to 50 per cent for all classes of carriers; and that the rule be made not applicable unless the cost of repairs exceed $1000.

Miscellaneous Changes

Regarding "Insurance," the rule that insurance recovered shall be credited to the primary account to which the losses are chargeable, instead of to the insurance premiums account, is restored in the April, 1927, draft.

Primary accounts "Ties," "Rails," "Other Track Material," and "Ballast," are eliminated from the operating expense classification—such charges to be made to the investment account.

Regarding accounting for operating expenses upon an accrual basis, in the case, for example, of loss and damage, injuries to persons, and similar expense items, and with reference also to "Equalization expenses," the proposed rules require that comprehensive statements indicating in each instance the plan of accrual or equalization be filed with the Commission and that no change be made without supplementary statement to the Commission. The carriers' representatives had made a general objection to provisions that the carriers must file with the Commission comprehensive statements of their methods of accruing unaudited revenues or expenses, for the reason that it would restrict initiative and experiments. In submitting the April, 1927, draft to the Accounting Officers' Association, the Bureau of Accounts advised the Association that careful consideration would be given to this feature of the classification before the new accounting rules are issued in final form. The carriers' committee also recommends that water line carriers be permitted to avail themselves of equalization accounting for operating expenses.

Regarding "Pensions and Relief," a plan is provided for establishing reserve to meet irrevocable and contractual liabilities for pensions. The carriers' committee, with reference to this, recommends that instead of providing a plan for establishing reserve for pensions, a rule be included (as previously urged) providing that to the "Pensions and Relief" account may be charged "premiums paid to insurance companies for annuity policies or amounts credited to reserves or turned over to trustees to represent the carrier's provision for pensions to employees currently retired."

The carriers' committee repeated its earlier recommendation that primary accounts be provided for: Work Train Expenses, Shop Expenses, Material Store Expenses, and Stationery Store Expenses—the reasons for which have previously been mentioned. It would also propose that balances in the accounts "Material Store Expenses" and "Stationery Store Expenses" be included in Balance Sheet Account 717—"Materials and Supplies," instead of 731—"Other unadjusted debits," as proposed in the tentative draft.

The recommendations previously submitted regarding consolidation of primary accounts, the charging of expenses for clearing wrecks, creation of a general account "Miscellaneous," to include valuation, pensions and relief, casualties accounts, and material and stationery store expenses, were renewed. A consolidation of primary accounts 207, Roadway Buildings, 209 Equipment Shops, and 215, Miscellaneous structures, into one account, styled "Roadway, Shop and Miscellaneous structures," is also recommended.

The general and primary accounts in the draft of April 26, 1927, are as follows:

General Accounts

I. Maintenance of way and structures
II. Maintenance of equipment
III. Transportation—Rail line
IV. Transportation—Water line
V. Miscellaneous operations
VI. Traffic
VII. General
VIII. Transportation for investment—Cr.

Primary Accounts

1. Maintenance of Way and Structures—
   - 201. Supervision
   - 202. Roadway and track repairs
   - 203. Tunnels
   - 204. Bridges
   - 205. Fences, snowsheds, crossings and signs
   - 206. Station and office buildings
   - 207. Roadway buildings
   - 208. Fuel and water stations
   - 214. Power transmission systems
   - 215. Miscellaneous structures
   - 216. Roadway machines and tools
   - 217. Roadway supplies
   - 218. Removing snow, ice and sand
   - 219. Public improvements
   - 220. Injuries to persons
   - 221. Stationery and printing
   - 222. Other expenses
   - 223. Maintaining joint tracks, yards, and other facilities—Dr.
   - 224. Maintaining joint tracks, yards, and other facilities—Cr
   - 225. Insurance
   - 226. Fixed improvements—Depreciation
   - 227. Extraordinary Repairs—Fixed improvements—Cr.
   - 228. Equalization—Way and structures
   - 229. Amortization—Way and structures

II. Maintenance of Equipment—
- 301. Supervision
- 302. Shop machinery
- 303. Power plant machinery
- 304. Locomotives—Repairs
- 305. Freight cars—Repairs
- 306. Passenger-train cars—Repairs
- 307. Floating equipment—Repairs
- 308. Work equipment—Repairs
- 309. Motor vehicles—Repairs
- 310. Injuries to persons
- 311. Stationery and printing
- 312. Other expenses
- 313. Maintaining joint equipment—Dr.
- 314. Maintaining joint equipment—Cr.
- 315. Insurance
- 316. Equipment—Depreciation
- 317. Extraordinary repairs—Equipment—Cr.
- 318. Equalization—Equipment
- 319. Amortization—Equipment

III. Transportation—Rail Line—
- 371. Supervision
- 372. Dispatching trains
- 373. Station employees
- 374. Weighing, inspection, and demurrage bureaus
- 375. Coal and ore wharves
- 376. Station supplies and expenses
- 377. Yardmasters and yard clerks
- 378. Yard conductors and brakemen
- 379. Yard switch tenders
- 380. Yard enginemen
- 381. Yard motormen
- 382. Fuel for yard locomotives
- 383. Yard switching power produced
- 384. Yard switching power purchased
- 385. Water for yard locomotives
- 386. Lubricants for yard locomotives
- 387. Other supplies for yard locomotives
- 388. Enginehouse expenses—Yard
- 389. Yard supplies and expenses
- 390. Train enginemen
- 391. Train motormen
- 392. Fuel for train locomotives
- 393. Train power produced
- 394. Train power purchased
- 395. Water for train locomotives
- 396. Lubricants for train locomotives
- 397. Other supplies for train locomotives
- 398. Enginehouse expenses—Train
- 399. Trainmen
- 400. Train supplies and expenses
- 401. Operating sleeping cars
- 402. Signal and interlocker operation
- 403. Crossing protection
- 404. Drawbridge operation
- 405. Telephone and telegraph operation
- 406. Water transfer operation
- 407. Operating motor vehicles

III. Transportation—Rail Line—Continued
- 408. Stationery and printing
- 409. Other expenses
- 410. Operating joint facilities—Dr.
- 411. Operating joint facilities—Cr.
- 412. Clearing wrecks
- 413. Damage to property
- 414. Damage to live stock on right-of-way
- 415. Loss and damage—Freight
- 416. Loss and damage—Baggage
- 417. Injuries to persons
- 418. Insurance
- 419. Equalization—Transportation

IV. Transportation—Water Line—
- 431. Operation of vessels
- 432. Operation of terminals
- 433. Incidental
- 434. Insurance

V. Miscellaneous Operations—
- 441. Dining and buffet service
- 442. Hotels and restaurants
- 443. Other miscellaneous operations

VI. Traffic—
- 451. Supervision
- 452. Solicitation
- 453. Development
- 454. Stationery and printing
- 455. Other expenses
- 456. Insurance
- 457. Equalization—Traffic

VII. General—
- 461. General officers
- 462. General office clerks and attendants
- 463. General office supplies and expenses
- 464. Law expenses
- 465. Pensions and relief
- 466. Stationery and printing
- 467. Valuation expenses
- 468. Other expenses
- 469. General joint facilities—Dr.
- 470. General joint facilities—Cr.
- 471. Insurance

VIII. Transportation for Investment—Cr.

PROPOSED REVISIONS OF CLASSIFICATION OF INCOME ACCOUNTS

The Bureau of Accounts circulated drafts of proposed classifications of Income Accounts dated June, 1926, October, 1926, and April, 1927. They provide for the inclusion in the income classification of all rents now carried in operating expenses. The income statement is modified to include an account "Net railway operating income."

In the June, 1926, draft, under "Special Instructions," it was proposed to provide for a clearing account to be maintained under the caption "Hire

of Freight Cars," and to include amounts receivable accrued as rent for use by others, either under lease or interchange arrangement, of freight-train cars owned or controlled by the accounting company; also amounts charged to investment accounts as rent of freight cars used in construction. To the clearing account it was proposed to charge amounts payable accrued as rent for use of freight-train cars of others, either leased or interchanged. Per diem reclaims receivable or payable were to be credited, or charged, as appropriate, to this clearing account. Such portion of compensation for freight cars leased as may be applicable as depreciation or maintenance would be included in operating expense accounts; and rent for cars covered in a lease of road agreement in Income accounts "Income from lease of road" or "Rent for leased roads," as might be appropriate.

In the subsequent drafts this instruction was eliminated and balancing accounts are provided for hire of equipment. They are intended to show the net balance for each month and annually. Balancing accounts are also proposed for contributions to cover profit and loss in the operation of properties which are separately operated; and for deficits receivable and income payable.

The balancing accounts proposed for hire of equipment consist of five accounts, 501—"Hire of freight cars," 502—"Hire of locomotives," 503—"Hire of passenger-train cars," 504—"Hire of floating equipment," and 505—"Hire of work equipment"; and are to include,

> "amounts receivable, accrued as rent from the use by others (except rents under lease for one year or more, or rents includible in the rent for lease of road accounts) of equipment owned or controlled by the carrier; also amounts charged to investment account as rent of equipment, when specifically assigned to construction projects."

And to these accounts,

> "shall be charged amounts payable, accrued as rent for the use of equipment of others except equipment held under lease for one year or more or equipment held under lease of road.
>
> "Per diem reclaims receivable shall be credited, and such reclaims payable shall be charged to these accounts.
>
> "In the statement of income for each fiscal period the balance in these accounts shall be shown in the appropriate account."

Under this arrangement, the hire of equipment (a) credit accounts and (b) debit accounts are to receive merely the credit or debit balances in the balancing accounts.

Balancing account 506, "Separately operated properties," is to include,

> "the amounts receivable under terms of agreement or contracts whereby the surplus for the fiscal period resulting from the operations of other carriers (having a separate corporate existence, including terminal carriers whose services are rendered entirely or primarily under published tariffs), is receivable in whole or in part, without obligation for reimbursement, by the carrier.
>
> "To this account shall be charged amounts payable under terms of agreements or contracts whereby the deficit for the fiscal period resulting from the operations of other carriers (having a separate corporate existence, including terminal carriers whose services are rendered entirely or partly under published tariffs), is payable in

whole or in part by the carrier without obligation for reimbursement to it.

"In determining the amounts receivable and the amounts payable by the carrier, consideration shall be given not only operating revenues and operating expenses, but also to other income or deductions which affect those amounts."

It is provided that dividends or other returns upon securities issued by separately operated companies and held or controlled by the carrier, be included in account "Dividend income," "Interest income," or "Income from sinking and other reserve funds," as may be appropriate, except that in these accounts there be respectively included for the fiscal period only the excess of the amounts receivable over the deficits payable. A terminal carrier operated for the joint benefit of two or more tenant companies is not to be considered a separately operated property to the extent of its operations for joint benefit. Such operations would be accounted for as joint facility operations.

The proposed balancing account "Deficits receivable and income payable," is intended to include amounts receivable from other companies representing all or a part of the net deficit of a carrier when, under terms of agreements or contracts, no obligation for subsequent reimbursement is incurred; and to this account would be charged all or any portion of the income of a carrier payable to other companies under terms of agreements or contracts, without obligation for reimbursement. The balance in this account would be shown for each fiscal period in the income statement, either in account "Deficits receivable from other companies," or "Income payable to other companies," as may be appropriate. Dividends or other payments on securities issued or assumed by the carrier would not be included in this account. Distribution by the carrier of its net income to other companies owning its capital stock, upon the basis of stock ownership, would be treated as a dividend distribution.

Regarding unaudited items affecting income accounts, an instruction is inserted providing for the estimating of appreciable items, the necessary adjustment to be made when an item is audited. If, in the interval, a substantial difference between the estimate and the actual amount is apparent, adjustment shall be made immediately, the carrier preserving a record of the information upon which the supplemental estimate is based.

Joint-Facility, Leased Road, and Miscellaneous Rent Accounts

The accounts for joint-facility, leased road, and miscellaneous rents in the income classification are rewritten and conform to the proposed change in accounting for rents, whereby all rents are excluded from the operating accounts and included in the rent accounts in income. In the tentative classification submitted in April, 1927, the text of these several accounts is as follows:

Credit Accounts

517. *Joint-Facility Rent Income*

This account shall include amounts receivable, accrued for rent under contracts or agreements covering the joint use of tracks,

yards, terminals, bridges, stations, towers, turntables, water stations, equipment and other facilities owned or controlled by the carrier and used by more than one carrier.

Amounts receivable from other companies in reimbursement for taxes on property jointly used shall be credited to this account.

Note A.—The portion of the cost of maintenance, operation, or administration of joint facilities, recoverable from others shall be credited to the various joint-facility accounts provided for operating expenses. When the compensation for the use of joint facilities is a fixed amount, or is based upon a charge per passenger, ton, car, or other unit, it shall be fairly apportioned by the creditor between this account and the appropriate joint-facility operating-expense accounts.

Note B.—All items, other than operating revenues and expenses, entering into joint-facility settlements between a terminal company and its tenant lines, shall be regarded as factors of rent in such settlements and included, respectively, in this account and account 538.

Note C.—Rents received for the exclusive use of property shall be credited to account 518 or account 519, as may be appropriate.

Note D.—The use of this account is conditional upon actual joint use of property. Amounts received from others for the right to use property jointly, such right not being exercised, shall be credited to account 527.

518. *Miscellaneous Rent Income*

This account shall include all rents receivable, not provided for elsewhere, from the use by others of carrier lands and structures thereon, or portions thereof, including rents for the use of space above or below that portion of the lands used by the carrier for transportation purposes, the rented property being owned or controlled by the carrier. It shall also include the rent from roadway machines and from miscellaneous equipment. The rents classable in this account are those from property, the cost of which is includible by the carrier in account 701, "Investment in road and equipment," or account 702, "Leased railway property," and also the rents from similar property sublet by the carrier.

If the compensations for the use of the property, the rent from which is includible in this account, cover the cost to the carrier of maintaining the property, such cost of maintenance shall be charged to this account, provided the amount is considerable and distinctly separable from the cost of maintaining other property of the carrier.

The following list of facilities will indicate the character of property, the rent from which is creditable to this account:

Elevators
Enginehouses
Ferry landings
Fuel yards
General and other office buildings
Miscellaneous equipment
Repair shops
Roadway machines
Section and other houses
Station buildings
Station stockyards
Warehouses
Wharves

Note A.—Taxes on carrier property shall be included in account 532 by the carrier assuming the taxes.

Note B.—Rent from property the cost of which is includible in account 705, shall be included in account 520.

Note C.—Rent and other income from real estate acquired for new lines before the beginning of carrier operations, shall be credited to the cost of the property acquired.

Note D.—When the property of the carrier is not used by it but is jointly used by others, the rents receivable from the users, if leased to them severally, shall be included by the carrier in account 517.

519. *Income from Lease of Road*

This account shall include rents (of all property covered in the lease or contract) receivable from the exclusive use by others of railroads owned or controlled by the carrier.

It shall include the rents receivable from equipment leased to others for a period of one year or more. It shall also include the rents receivable from the exclusive use by others of railway bridges, tunnels, or tracks.

The rents are creditable to this account whether receivable in cash or distributed by the lessee in behalf of the carrier as interest on funded debt, guaranteed dividends on stock, or otherwise.

If, under the terms of the lease, the deficit or any portion thereof resulting from the lessee's operation of the leased property is assumed by the lessor, the amount thus assumed shall be treated as a reduction in the rent creditable to this account.

When the compensation for the property, the rent from which is includible in this account, covers the cost to the carrier of maintaining the rented property, the cost of maintenance shall be charged to this account.

Note A.—Taxes on leased carrier property shall be included in account 532 by the carrier assuming the taxes.

Note B.—Rents accrued for the hire of equipment that is not included in the agreement for lease of road; is not leased for one year or more; or is not jointly used, shall be accounted for in the appropriate hire of equipment accounts.

Note C.—Rents accrued for the joint use of carrier property are includible in the joint-facility rent accounts payable severally by the users thereof.

Debit Accounts

538. *Joint-Facility Rents*

This account shall include amounts payable accrued as rent under contracts or agreements covering the joint use of tracks, yards, terminals, bridges, stations, towers, turntables, water stations, equipment, and other facilities owned or controlled by other carriers, companies, or individuals, and in the joint use of which the carrier participates.

Amounts paid or payable by the carrier in reimbursement for taxes on property jointly used shall be charged to this account.

Note A.—The portion of the cost of maintenance, operation, or administration of joint facilities chargeable to the carrier, shall be charged to the various joint-facility accounts provided for operating expenses. When the compensation for use of joint facilities is a fixed amount or is based upon a charge per passenger, ton, car, or other unit, it shall be fairly apportioned between this account and the appropriate joint-facility operating-expense accounts. This apportionment shall be made by the operating company and shall be followed by the carrier.

Note B.—All items other than operating revenues and operating expenses entering into joint-facility settlements between a terminal company and its tenant lines shall be regarded as factors of rent in such settlements and included, respectively, in account 517 and in this account.

Note C.—Rents payable for the exclusive use of property shall be charged to account 539 or account 540, as may be appropriate.

Note D.—The use of this account is conditional upon actual joint use of property. Amounts payable to others for the right to use property jointly, such right not being exercised, shall be charged to account 548 (Miscellaneous income charges).

539. *Miscellaneous Rents*

This account shall include all rents payable, not provided for elsewhere, for the exclusive use, for carrier purposes, of lands and structures thereon, or portions thereof, including rents for use of space above or below that portion of lands used by the lessor, and also the rent of roadway machines and of miscellaneous equipment.

The rents classable in this account are those for property the cost of which, if owned by the carrier, would be includible in account 701, "Investment in road and equipment," or account 702, "Leased railway property."

The following list of facilities will indicate the character of property the rent for use of which is chargeable to this account.

Automatic weight-recording devices for scales.
Buildings or rooms for trainmen.
Buildings or warehouses for storing unclaimed and damaged freight baggage
Offices used for railway transportation purposes.
Pile drivers not mounted for movement on carrier's tracks.
Right-of-way for water pipelines for locomotive supply.
Scales for stations.
Snow and sand fences, privilege of erecting.
Sources of water supply.
Stalls in roundhouses.
Station buildings.
Storehouses for company material.
Tabulating machines.
Telegraph and telephone conduits.

Note A.—If leased property the rent for which is chargeable to this account is sublet to others, rent receivable therefor shall be credited to the account appropriate for rent from owned property of the same class.

Note B.—Taxes on property the rent for which is chargeable to this account shall be included in account 532 by the carrier assuming the taxes.

Note C.—Rents accrued, payable for property used by the carrier for other than carrier purposes, shall be included in account 520. (Income from miscellaneous physical property.)

Note D.—Rents accrued, payable for property used in the construction of original railroad before the property is available for commercial operations, shall be included in the appropriate road and equipment accounts.

Note E.—Rents payable for facilities jointly used by the carrier and other carriers shall be included in account 538.

Note F.—When rented property is not used by the lessor but is jointly rented by the carrier and other users, the rent payable shall be included in account 538.

540. *Rent for Leased Roads*

This account shall include the rents (of all property covered

in the lease or contract) payable for the exclusive use of railroads owned or controlled by others.

It shall include the rents payable for equipment leased from others for a period of one year or more. It shall also include the rents payable for the exclusive use of railway bridge, tunnels, or tracks of others.

The rents are chargeable to this account whether payable in cash or disbursed by the lessee in behalf of the lessor as interest on funded debt, guaranteed dividends on stock, or otherwise.

If under the terms of the lease the deficit or any portion thereof resulting from the lessee company's operation of the leased property is assumed shall be treated as a reduction in the rent chargeable to this account.

When the compensation for the property, the rent for which is includible in this account, covers the cost to the lessor of maintaining the rented property, the cost of maintenance shall be charged by the lessee to Operating Expenses and the remainder of the compensation shall be charged to this account.

Note A.—Taxes on leased carrier property shall be included in account 532 by the carrier assuming the taxes.

Note B.—If leased property, the rent for which is chargeable to this account, is sublet to others, rent receivable therefor shall be credited to the account appropriate for rent from owned property of the same class.

Note C.—Rents accrued for the joint use of carrier property are includable in the joint-facility rent accounts.

Note D.—Rent for equipment, that is not included in the agreement for lease of road, is not leased for one year or more or is not jointly used, shall be accounted for in the appropriate hire of equipment accounts.

List of Primary Accounts

The primary accounts proposed in the April, 1927, draft are as follows:

I. Balancing Accounts—

501. Hire of freight cars
502. Hire of locomotives.
503. Hire of passenger-train cars
504. Hire of floating equipment.
505. Hire of work equipment.
506. Separately operated properties.
507. Deficits receivable and income payable.

II. Credit Accounts—

511. Railway operating revenues.
512. Hire of freight cars—Credit balance.
513. Hire of locomotives—Credit balance.
514. Hire of passenger-train cars—Credit balance.
515. Hire of floating equipment—Credit balance.
516. Hire of work equipment—Credit balance.
517. Joint-facility rent income.
518. Miscellaneous rent income.
519. Income from lease of road.
520. Income from miscellaneous physical property.
521. Separately operated properties—Profit.
522. Dividend income.
523. Interest income.
524. Income from sinking and other reserve funds
525. Release of premium on funded debt.
526. Deficits receivable from other companies.
527. Miscellaneous income

III. Debit Accounts—

531. Railway operating expenses.
532. Railway tax accruals.
533. Hire of freight cars—Debit balance.
534. Hire of locomotives—Debit balance.
535. Hire of passenger-train cars—Debit balance.
536. Hire of floating equipment—Debit balance.
537. Hire of work equipment—Debit balance.
538. Joint-facility rents.
539. Miscellaneous rents.
540. Rent for leased roads.
541. Miscellaneous tax accruals.
542. Separately operated properties—Loss.
543. Interest on funded debt.
544. Interest on unfunded debt.
545. Amortization of discount on funded debt.
546. Maintenance of investment organization.
547. Income payable to other companies.
548. Miscellaneous income charges.
549. Reservations of income for property investment.
550. Reservations of income for retirement of debt.
551. Miscellaneous reservations of income.
552. Stock discount extinguished through income.
553. Dividend appropriations of income.

Recommendations by the Carriers' Association

The representatives of the Accounting Officers' Association suggest several modifications in the proposed classification. Regarding dividends or other returns upon securities issued by separately operated companies and held or controlled by the carrier, it was recommended that the provision in proposed balancing account 506 (see above) that there be included for the fiscal period only the excess of the amounts receivable over the deficits payable, be eliminated. It was also recommended that the proposed rule that a joint terminal carrier be considered a separately operated property and its operations for joint benefit of tenant companies be accounted for as a joint-facility operation, be eliminated.

The proposed classification would include in the account "Miscellaneous rent income," rents "for the use of space above or below that portion of the lands used by the carrier for transportation purposes, the rented property being owned or controlled by the carrier." The carriers' representatives contend that amounts received for the use of such space should go to the account "Miscellaneous income." They further recommend that proposed account 519 "Income from lease of road," be eliminated, and that the present effective account remain unchanged.

They also recommend that penalties for non-payment of taxes be included in the account "Railway tax accruals"; that in account "Interest on Unfunded Debt," the interest on overcharge be charged the same as the principal to avoid undue refinement of accounting; and that (a) "cost of advertising bonds drawn for redemption," (b) "cost of trusts, current expenses of maintaining and administering," and (c) "losses due to conversion of funds of a foreign country into U. S. funds," instead of being charged to account 548 "Miscellaneous Income Charges," be included as operating expenses.

Form of Income Statement

The proposed form of income statement (draft of April, 1927), as compared with the present form, is as follows:

Present Form

I. Operating Income—
- 501. Railway operating revenues.
- 531. Railway operating expenses.
  - Net revenue from railway operations.
- 532. Railway tax accruals.
- 533. Uncollectible railway revenues.
  - Railway operating income.
- 502. Revenues from miscellaneous operations.
- 534. Expenses of miscellaneous operations.
  - Net revenue from miscellaneous operations.
- 535. Taxes on miscellaneous operating property.
  - Miscellaneous operating income.
    - Total operating income.

II. Non-operating Income—
- 503. Hire of freight cars—Credit balance.
- 504. Rent from locomotives.
- 505. Rent from passenger-train cars.
- 506. Rent from floating equipment.
- 507. Rent from work equipment.
- 508. Joint-facility rent income.
- 509. Income from lease of road.
- 510. Miscellaneous rent income.
- 511. Miscellaneous non-operating physical property.
- 512. Separately operated properties—Profit.
- 513. Dividend income.
- 514. Income from funded securities.
- 515. Income from unfunded securities and accounts.
- 516. Income from sinking and other reserve funds.
- 517. Release of premiums on funded debt.
- 518. Contributions from other companies.
- 519. Miscellaneous income.
  - Total non-operating income.
    - Gross income (or loss).

III. Deductions from Gross Income—
- 536. Hire of freight cars—Debit balance.
- 537. Rent for locomotives.
- 538. Rent for passenger-train cars.
- 539. Rent for floating equipment.
- 540. Rent for work equipment.
- 541. Joint-facility rents.
- 542. Rent for leased roads.
- 543. Miscellaneous rents.
- 544. Miscellaneous tax accruals.
- 545. Separately operated properties—Loss.
- 546. Interest on funded debt.
- 547. Amortization of discount on funded debt.
- 549. Maintenance of investment organization.
- 550. Income transferred to other companies.
- 551. Miscellaneous income charges.
  - Total deductions from gross income.
    - Net income (or loss).

IV. Disposition of Net Income

552. Income applied to sinking and other reserve funds.
553. Dividend appropriations of income.
554. Income appropriated for investment in physical property
555. Miscellaneous appropriations of income.
Total appropriations.
Income balance transferred to credit (or debit) of Profit and Loss.

Proposed Form

I. Railway Operating Income.

511. Railway operating revenues.
531. Railway operating expenses.
Net revenue from railway operations.
532. Railway tax accruals.
Railway operating income.

Rent Income—

512. Hire of freight cars—Credit balance.
513. Hire of locomotives—Credit balance.
514. Hire of passenger-train cars—Credit balance.
515. Hire of floating equipment—Credit balance.
516. Hire of work equipment—Credit balance.
517. Joint-facility rent income.
518. Miscellaneous rent income.
Total rent income.
Total railway operating income.

Rents Payable—

533. Hire of freight cars—Debit balance.
534. Hire of locomotives—Debit balance.
535. Hire of passenger-train cars—Debit balance.
536. Hire of floating equipment—Debit balance.
537. Hire of work equipment—Debit balance.
538. Joint-facility rents.
539. Miscellaneous rents.
Total rents payable.
Net railway operating income.

II. Other Income—

519. Income from lease of road.
520. Income from miscellaneous physical property.
521. Separately operated properties—Profit.
522. Dividend income.
523. Interest income.
524. Income from sinking and other reserve funds.
525. Release of premium on funded debt.
526. Deficits receivable from other companies.
527. Miscellaneous income.
Total other income.
Total income.

III. Deductions from Total Income—

540. Rent for leased roads.
541. Miscellaneous tax accruals
542. Separately operated properties—Loss.
543. Interest on funded debt.
544. Interest on unfunded debt.

III. Deductions from Total Income—Continued

545. Amortization of discount on funded debt.
546. Maintenance of investment organization.
547. Income payable to other companies.
548. Miscellaneous income charges.

Total deductions from income.

Net income.

IV. Disposition of Net Income—

549. Reservations of income for property investment.
550. Reservations of income for retirement of debt.
551. Miscellaneous reservations of income.
552. Stock discount extinguished through income.
553. Dividend appropriations of income.

Total appropriations of income.

Balance transferred to Profit and Loss.

PROPOSED REVISIONS OF CLASSIFICATION OF PROFIT AND LOSS ACCOUNTS

Drafts of a revised classification of Profit and Loss accounts were circulated in June and October, 1926, and in April, 1927. The first draft was revised in some respects by the second draft, but the second and third drafts are substantially alike.

The proposed instructions contain a provision that these accounts be written up currently for each month. A provision appears regarding unaudited items, as in the case of Income accounts, to the effect that when the amount of a known appreciable item affecting Profit and Loss can not be accurately determined in time for inclusion in the accounts of the calendar year in which the transaction occurs, the amount of the item shall be estimated and included in Profit and Loss, and credited to account 779, Other unadjusted debits, as may be appropriate, the necessary adjustment being made when the item is audited. If, during the interval between the date of inclusion of the item in the accounts and the date on which it is audited, a substantial difference is determined between the initial estimate and the actual amount of the item, appropriate adjustment is at once to be made in the accounts to cover such difference. The carrier is to preserve in its files a record of the information upon which the supplemental estimate is based.

Account 603, "Profit on road and equipment sold," which includes the net proceeds from sale of road and equipment property in excess of its ledger value at time of sale, is modified by a note to the effect that:

> "Proceeds realized in the settlement under American Railway Association, Mechanical Division, reciprocal rules for equipment destroyed on foreign lines shall be considered as salvage from the retired equipment."

The representatives of the Accounting Officers' Association recommend the exclusion of this account and transfer of its text to the account, "Miscellaneous credits."

Regarding donations, the present accounting rules provide that donations made by states, municipalities, and other public corporations toward the acquisition or improvement of property shall be included in balance

sheet account 654, "Grants in aid of construction," instead of profit and loss account 606, "Donations." This rule is not changed in the tentative revised classification. However, the representatives of the carriers' association recommend that the latter account be modified to include all donations, whether made by governmental bodies or by individuals and companies, and that the former account in the balance sheet classification be eliminated. The proposed classification contains a rule that contributions by others toward the cost of joint projects shall not be accounted as donations.

The debit account, "Loss on retired road and equipment," which includes charges to profit and loss on account of carrier road and equipment abandoned, sold, or otherwise retired, is modified to include also the ledger value, less accrued depreciation, if any, of improvements on leased railway property upon reversion to the lessor. The carriers' representatives recommend the elimination of the account, the inclusion of loss from land retirements in account 615, "Miscellaneous debits," and the charging of all other property abandoned to operating expenses.

With further regard to the account "Miscellaneous Debits," the present rules provide that penalties and fines for violation of the Interstate Commerce Act or other Federal laws be there included in profit and loss. This rule is not changed in the tentative revision, but the Accounting Officers' committee recommends that such items be charged to operating expenses.

In regard to accounting for "Reservations of surplus for property investment," it is proposed in the tentative classification that a carrier's records show separately appropriations for investment in carrier and non-carrier property. Also, that if the amounts charged to this account in profit and loss represent expenditures already made, they shall be credited to balance-sheet account "Additions to property through income and surplus"; that if they cover expenditures to be made in the future, they shall be concurrently credited to balance-sheet account "Miscellaneous reserves," and when invested in physical property they shall be charged to that account and credited to the account "Additions to property through income and surplus."

A new debit account, "Donation reservations," is included to contain amounts of donations in aid of construction, made by individuals and companies. The carrier's accounting committee recommends that it not be restricted to donations by "individuals and companies," but include all donations.

A new debit account is inserted, "Reservations of surplus for retirement of debt," the proposed text of which is as follows:

> "This account shall include amounts of surplus set aside for retirement of the debt of the carrier. It shall include amounts definitely appropriated and set aside in special funds and also appropriations which are only indicated by a reserve account, the appropriations not being segregated from the general funds of the corporation. It includes allotments or payments of definite amounts of surplus under the terms of mortgages, deeds of trust, or other contracts providing for such allotments or payments.
>
> "Note A—The amounts charged to this account shall be concurrently credited to account 783 (Debt retirement reserves).

"Note B—Similar appropriations made from Income shall be charged to account 550 (Reservations of income for retirement of debt)."

The account "Stock discount extinguished through surplus," is modified to include a provision that the use of the account is conditional upon the carrier having an adequate credit balance in Profit and Loss.

The present note "B" in the present account "Dividend appropriations of surplus," to the effect that this account shall not include charges for dividends on capital stock issued or assumed, and owned, by the carrier, whether pledged as collateral or held in its treasury, in special deposits, or in sinking or other funds, is modified in the proposed classification to except from this provision such stock as may be reacquired by the trustees of sinking or other special funds—the securities being subject to resale, as distinguished from stock reacquired for the purpose of cancellation or retirement.

The primary accounts of the proposed revision (April, 1927, draft) as compared with the present effective classification, are as follows:

Primary Accounts

Present	*Proposed*
I. Credits	I. Credit Accounts
601. Credit balance (at beginning of fiscal period).	601. Credit balance (at beginning of calendar year).
602. Credit balance transferred from Income	602. Credit balance transferred from Income
603. Profit on road and equipment sold	603. Profit on road and equipment sold
604. Delayed income credits.	604. Delayed income credits
605. Unrefundable overcharges	605. Donations
606. Donations	606. Miscellaneous credits
607. Miscellaneous credits	
II. Debits	II. Debit Accounts
611. Debit balance (at beginning of fiscal period)	611. Debit balance (at beginning of calendar year)
612. Debit balance transferred from income	612. Debit balance transferred from Income
613. Surplus applied to sinking and other reserve funds	613. Delayed income debits
614. Dividend appropriations of surplus	614. Loss on retired road and equipment
615. Surplus appropriated for investment in physical property	615. Miscellaneous debits
616. Stock discount extinguished through surplus	616. Reservations of surplus for property investment
617. Debt discount extinguished through surplus	617. Donation reservations
618. Miscellaneous appropriations of surplus	618. Reservations of surplus for retirement of debt
619. Loss on retired road and equipment	619. Miscellaneous reservations of surplus
620. Delayed income debits	620. Stock discount extinguished through surplus
621. Miscellaneous debits	621. Dividend appropriations of surplus

TENTATIVE CLASSIFICATION OF BALANCE SHEET ACCOUNTS

Drafts of a proposed revision of the Balance Sheet were circulated in October, 1926, and April, 1927. The latter draft includes new accounts as follows:

Asset side:

Leased miscellaneous physical property.
Road leased to others.
Past accrued depreciation—Jan. 1, 1928.
Taxes paid in advance.

Liability side:

Road leased from others.
Donation reserves.

It omits account 783, "Appropriated surplus not specifically invested."

The instructions governing the balance sheet accounts in the proposed revised classification provide that verification be made currently of all suspense and open accounts. While this rule is now followed by many companies, the new instruction would make the practice mandatory. The Accounting Officers' committee recommends that the provision be eliminated.

It is proposed that the ledger value, as shown on lessor's books, of railroads leased under such terms and conditions, and for a period of sufficient duration, as substantially to vest in the lessee ownership of the property, be carried into the balance sheet accounts for investment; the charge to be made to account 702, "Leased railway property," concurrently crediting the same amount to a new liability account 758, "Road leased from others." Correspondingly, the lessor shall credit account 701, "Investment in road and equipment," and charge new asset account 723, "Road leased to others." Additions and betterments and retirements of property thus held shall be accounted for through account 702, "Leased railway property." The carriers' committee recommends that the instruction specify that the ledger value be estimated if not known. The purpose of the proposed rule is to have the returns of the carriers to the Commission include the ledger value of property owned by inactive non-operating companies as well as all other carrier property.

To secure uniform accounting for items included in the "Cash" account, it is proposed that a carrier shall show the entire amount of cash on hand without deduction for voucher, checks, etc., outstanding.

Expenses incident to the issuance and sale of evidence of funded debt, including, for example, fees for drafting mortgages and trust deeds, cost of engraving and printing bonds, and other certificates of indebtedness, fees paid to trustees and fees paid for legal services to trustees, fees and commissions paid underwriters and brokers, and the cost of obtaining governmental authority to issue funded debt, and similar expenses, are now included in income as an expense of funded debt, and no change is proposed in this rule. The Accounting Officers' committee recommends that such expenses be included in operating expenses; and also the expense of subsequent issues of capital stock.

The Accounting Officers' committee has also recommended a new account in the balance sheet to be "Investment in securities issued, assumed, or otherwise carried as a liability by the accounting company."

Account 701, "Investment in road and equipment," is completely rewritten in the proposed revised classification, and made to read as follows:

701. *Investment in Road and Equipment*

This account shall include the cost to the carrier of land, fixed improvements, and equipment (acquired for transportation purposes and in existence at the date of the balance sheet) which are owned by it and are used by it or others (except as provided in note C and in account 723, "Road leased to others") in transportation service. It shall also include the carrier's investment in physical property which is owned and held for imminent use for transportation service, but not so used at date of the balance sheet. The carrier's records shall be so kept as to show the charges and credits to this account classified in accordance with the Classification of Investment in Road and Equipment and also to show separately those relating to property used and to property leased to others, the rent receivable for which is includible in account 519, "Income from lease of road."

Note A—This account shall not include any item representing titles to securities.

Note B—When any equipment or other railway property is acquired under an agreement which provides that the cost shall be paid in installments, the cost (its money value at time of purchase) shall be charged to the appropriate road and equipment accounts at the time of its acquisition, and included in this account in the same manner as the cost of property purchased outright. When the par value of notes or other securities issued in payment, or in part payment, for such property is more or less than its actual cash value at the time of the purchase, or of the proportion of the value to which the securities are applicable, the difference between the par value of the securities and the actual cash value of the property, or of the proportion of the value paid for by the securities, shall be charged or credited to the proper discount and premium account.

Note C—The carrier's investment in railway material leased to others, such as metal bridges, rails and track fastenings, even though used by others for transportation purposes, shall be included by the carrier in account 705 (i. e., Miscellaneous physical property).

The Accounting Officers' committee would eliminate, in Note C, the words: "even though used by others for transportation purposes"; and make the same omission in a similar note inserted in account "Material and supplies."

Account 702, "Leased railway property," is also completely rewritten as follows:

701. *Leased Railway Property*

This account shall include the carrier's investment in additions and betterments to property used by it in transportation service which is held by it under lease or through control of the corporation owning the property (the rent for which is chargeable to account 540, "Rent for leased roads"). It shall also include the ledger value (as shown in the books of the lessor) of road and equipment property of others held under lease (the rent of which is chargeable

to account 540, "Rent for leased roads") under such circumstances and of sufficient duration substantially to vest in the lessee ownership of the property, the lessor's asset being merely of a deferred character—includible in account 723, "Road leased to others." The carrier's records shall be so kept as to show the charges and credits to this account classified in accordance with the Classification of Investment in Road and Equipment.

Note A—This account shall not include any items representing titles to securities.

Note B—When under the terms of the lease improvements to leased railway property made by the lessee revert to the lessor at the termination of the lease (without reimbursement to the lessee) the value of the improvements at date of reversion in excess of the amounts provided for the retirement of the property through charges to operating expenses, shall be included by the lessee in account 614. (i. e., Profit and Loss account, "Loss on retired road and equipment").

The Accounting Officers' committee propose substitution, in the second sentence, of the word "may" for "shall." The second paragraph was added primarily on account of the Commission's depreciation order.

Account 704 is entitled, in the tentative draft, "Deposits under mortgage provision"; and is intended to include funds deposited with trustees until mortgaged property sold is replaced, and proceeds from the carrier's securities sold which are to be held until invested in physical property by the carrier.

Account 706 becomes, in the tentative draft, "Leased miscellaneous physical property"; the text of which reads as follows:

706. *Leased Miscellaneous Physical Property*

This account shall include the ledger value (as shown on the books of the lessor) of miscellaneous physical property held by the carrier under lease of road under such conditions and of sufficient duration substantially to vest in its ownership of the property (the lessor's asset in the property being merely of a deferred character —includible in account 723, "Road leased to others"). It shall also include the carrier's investment in additions and betterments to such property held under lease.

Note.—When under the terms of the lease, improvements to leased miscellaneous physical property made by the lessee revert to the lessor at the termination of the lease (without reimbursement to the lessee) the value of the improvements at date of reversion in excess of amounts provided for the retirement of the property through account 520 shall be included by the lessee in account 615 (i. e., Profit and Loss account, "Miscellaneous Debits").

The account "Materials and Supplies" is rewritten as follows:

717. *Material and Supplies*

This account shall include the balances representing the cost, less depreciation, if any, of all unapplied material and supplies, such as roadway and shop material, articles in process of manufacture by the carrier, fuel, stationery, and dining car and other supplies. In determining the cost of material and supplies suitable allowance shall be made for all discounts allowed in the purchase thereof.

The costs chargeable to this account are the actual cash costs of the material and supplies at the point of free delivery plus any transportation charges paid for transporting the material from the free delivery point to the carrier's lines.

Material recovered in connection with maintenance work or the demolishing of fixed improvements or equipment shall be charged to this account on the basis of its value as recovered. When scrap material is sold at a higher or lower price than that at which it is included in this account, so far as practicable, an appropriate adjustment should be made in the account which was credited with the material recovered when included in the material and supply account.

Note A.—Interest paid on material bills, the payments of which are delayed, shall be charged to account 544 (i. e., Income account "Interest on unfunded debt").

Note B.—An annual inventory of material and supplies shall be taken and the necessary adjustment to bring this account into harmony with the actual inventory balances shall be made. In effecting this adjustment determined differences in accounting for important classes of material shall be equitably assigned among the accounts to which the classes of material are ordinarily chargeable. Other differences shall be apportioned among the primary accounts upon the basis of material charges since the last inventory.

Note C.—The carrier's investment in railway material leased to others, such as metal bridges, rails and track fastenings, even though used by others for transportation purposes, shall be included by it in account 705.

The Accounting Officers' committee recommend elimination of Note A, and from Note C the words, "even though used by others for transportation purposes."

That committee also proposes elimination of a proposed new account "Taxes paid in advance," and proposes that it be combined with the account "Rents and Insurance Premiums paid in advance," with appropriate change in the title of the latter account. The committee also recommends complete elimination of account 754, "Grants in aid of construction"; and proposes also the elimination of the accounts "Additions to property through income and surplus," and "Funded debt retired through income and surplus." Regarding the two latter accounts, the Bureau of Accounts explains that they were provided for the convenience of carriers in showing invested surplus distinctly from other profit and loss balances, and doubts that they should be eliminated.

In the matter of funded debt matured and unpaid, the Bureau's tentative draft is made to include receiver's certificates matured and unpaid, with other funded debt. The Accounting Officers' committee recommends a separate account for receivers' certificates.

The tentative draft substitutes for present account 774, "Operating reserves," an account 775, "Equalization reserves," which reads as follows:

775. *Equalization Reserves*

This account shall include the net balance between the total amounts charged and the total amounts credited to the equalization accounts in Operating Expenses.

The balances in this account as of the close of each year shall be extinguished through the equalization accounts in Operating Expenses in the accounts for the month of December.

The account shall be so kept as to show separately the amounts of the reserves on account of Maintenance of Way and Structures, Maintenance of Equipment, Transportation, and Traffic.

The carriers' committee propose elimination of the second paragraph and in place thereof the following:

> "All equalization reserve accounts at the close of the year shall be cleared through the accounts used in creating the reserves."

The present three accounts for accrued depreciation—road, equipment, and miscellaneous physical property, are retained, becoming accounts 776, 777, and 778, respectively; the first two being substantially changed, however, to meet the requirements of the depreciation order. They are all three modified to provide that when fixed property, or miscellaneous physical property "is destroyed, sold, or otherwise retired from service, the service value thereof shall be charged thereto." The following requirement is also inserted in the accounts 776 and 777:

> The carriers shall keep the details of this account in such a manner as to show separately for each period, (a) the balance in the account at the beginning of the period, (b) the credits thereto during the period, (c) the charges thereto during the period, and (d) the balance therein at the end of the period, and the amounts shown under each of the foregoing headings shall be subdivided to show the amount relating to each depreciable "Fixed improvement" (or "Equipment," as the case may be) account.

It is further provided by note that:

> When the compensation for use of fixed improvements, held under lease, covers rent and depreciation (the lessee being responsible for the current repairs) the current charges covering the depreciation thereof shall be charged by the lessee to account 226, "Fixed Improvements—Depreciation" (or 316—"Equipment—Depreciation") and credited to the account to which the rent of the property is chargeable. Correspondingly, the lessor shall charge the portion covering the depreciation to the appropriate rent account in income and credit it to account 776, "Accrued Depreciation—Road." (or 777, "Accrued Depreciation—Equipment," as the case may be).

The Accounting Officers' committee recommends that these accounts, instead of providing for the crediting of amounts covering depreciation of road and equipment "classable in accounts 701, 'Investment in road and equipment,' and 702, 'Leased railway property,'" should state that they are to be credited with amounts charged to operating expenses, or other accounts, to cover the depreciation of road and equipment, "for which the accounting carrier is responsible as to maintenance, renewals, and replacements."

Because of the Commission's depreciation order, No. 15100, an account is added, "Past accrued depreciation—January 1, 1928," numbered 724.

The account "Insurance and casualty reserves," is rewritten as follows:

> 774. *Insurance and Casualty Reserves*
>
> This account shall be credited with amounts of surplus definitely reserved to insure against loss through fire and other casualties. To this account shall also be credited insurance premiums charged to the investment in road and equipment accounts, to the insurance accounts in operating expenses, to store expenses clearing accounts, to account 520, "Income from miscellaneous physical property," or to other accounts to cover losses through casualties or other causes.

To this account shall be charged insurance premiums paid to others for reinsurance.

To this account shall also be charged the amount of the losses insured therein.

This account shall only be used under the condition that the carrier reserves and maintains therein an amount adequate to cover the risks assured through the insurance premiums credited thereto and not reinsured.

A proposed instruction, "Investment securities," reads as follows:

704. *Investment Securities*

Securities issued by the carrier and securities issued by other companies the obligation for payment of which has been assumed by the carrier, when reacquired for investment by the trustees of sinking or other special funds in which others than the carrier are interested—the securities being subject to resale—shall be stated in the appropriate fund accounts at cost and shall be classed as actually outstanding. Otherwise, such securities reacquired by the carrier shall be stated in its accounts at par.

A proposed instruction, "No par value capital stock," reads as follows:

710. *No Par Value Capital Stock*

(a) When capital stock of no par value has been actually issued to a bona fide holder for value and is reacquired for retirement by the carrier, account 751 "Capital stock," shall be charged with the amount of the liability resting therein with respect to the reacquired stock. The amount thus charged shall be determined by a prorate of the proceeds realized from the shares of the particular subclass of stock of which the shares reacquired are a part actually outstanding immediately prior to the reacquisition. The difference between the amount by which the liability in the capital stock account is reduced and the amount expended in reacquiring the stock, shall be adjusted through profit and loss account 606, "Miscellaneous credits," or 615, "Miscellaneous debits," as may be appropriate.

(b) If for any reason it is necessary to hold the stock alive before retirement, the prorata proceeds from the sale of the shares shall be charged in the short column of the balance sheet to account 732, "Securities issued or assumed—Unpledged," or account 733, "Securities issued or assumed—Pledged," as may be appropriate, and an equal amount in account 751, "Capital stock," shall be transferred from the long to the short column of the balance sheet.

(c) Nominally issued no par value capital stock shall not be included in the body of the balance sheet, but shall be included in a supplementary statement accompanying the balance sheet.

Form of Balance Sheet

The form of the balance sheet in the proposed classification (draft of April, 1927), as compared with the present form, is as follows:

Present	*Proposed*
Asset Side	Asset Side
Investments:	Investments:
701. Investment in road and equipment.	701. Investment in road and equipment.
702. Improvements on leased railway property.	702. Leased railway property.
	703. Sinking funds.

Form of Balance Sheet—Continued

Present

Asset Side

703. Sinking funds.
    Total book assets at date. (In short column.)
    Carrier's own issues at date. (In short column.)
    Other assets at date. (In long column.)
704. Deposits in lieu of mortgaged property sold.
    Total book assets at date. (In short column.)
    Carrier's own issues at date. (In short column.)
    Other assets at date. (In long column.)
705. Miscellaneous physical property.
706. Investments in affiliated companies.
    (a) Stocks.
    (b) Bonds.
    (c) Notes.
    (d) Advances.
707. Other investments.
    (a) Stocks.
    (b) Bonds.
    (c) Notes.
    (d) Advances.
    (e) Miscellaneous.
    Total.

Current Assets:

708. Cash.
709. Demand loans and deposits.
710. Time drafts and deposits.
711. Special deposits.
    Total book assets at date. (In short column.)
    Carrier's own issues at date. (In short column.)
    Other assets at date. (In long column.)
712. Loans and bills receivable.
713. Traffic and car-service balances receivable.
714. Net balance receivable from agents and conductors.
715. Miscellaneous accounts receivable.
716. Material and supplies.
717. Interest and dividends receivable.
718. Rents receivable.
719. Other current assets.
    Total.

Proposed

Asset Side

Total book assets. (In short column.)
*Carrier's own issues. (In short column.)
Other assets. (In long column.)
704. Deposits under mortgage provisions.
    Total book assets. (In short column.)
    *Carrier's own issues. (In short column.)
    Other assets. (In long column.)
705. Miscellaneous physical property.
706. Leased miscellaneous physical property.
707. Investments in affiliated companies.
    (a) Stocks.
    (b) Bonds.
    (c) Notes.
    (d) Advances.
708. Other investments.
    (a) Stocks.
    (b) Bonds.
    (c) Notes.
    (d) Advances.
    (e) Miscellaneous.
    Total.

Current Assets:

709. Cash.
710. Demand loans and deposits.
711. Time drafts and deposits.
712. Special deposits.
    Total book assets. (In short column.)
    *Carrier's own issues. (In short column.)
    Other assets. (In long column.)
713. Loans and bills receivable.
714. Traffic and car-service-debit balance.
715. Agents' and conductors' balances.
716. Miscellaneous accounts receivable.
717. Material and supplies.
718. Interest and dividends receivable.
719. Rents receivable.
720. Other current assets.
    Total.

Form of Balance Sheet—Continued

Present

Deferred Assets:

720. Working fund advances.
721. Insurance and other funds.
    Total book assets at date. (In short column.)
    Carrier's own issues at date. (In short column.)
    Other assets at date. (In long column.)
722. Other deferred assets.
    Total.

Unadjusted Debits:

723. Rents and insurance premiums paid in advance.
724. Discount on capital stock.
725. Discount on funded debt.
726. Property abandoned chargeable to operating expenses.
727. Other unadjusted debts.
728. Securities issued or assumed—Unpledged. (In short column only.)
729. Securities issued or assumed—Pledged. (In short column only.)
    Total.

Liability Side

Stock:

751. Capital stock.
    Book liability at date. (In short column.)
    Held by or for carrier at date. (In short column.)
    Actually outstanding at date. (In long column.)
752. Stock liability for conversion.
753. Premium on capital stock.
    Total.

Governmental Grants:

754. Grants in aid of construction.

Long Term Debt:

755. Funded debt unmatured.
    Book liability at date. (In short column.)
    Held by or for carrier at date. (In short column.)
    Actually outstanding at date. (In long column.)
756. Receiver's certificates.

Proposed

Deferred Assets:

721. Working fund advances.
722. Insurance and other funds.
    Total book assets. (In short column.)
    *Carrier's own issues. (In short column.)
    Other assets. (In long column.)
723. Road leased to others.
724. Past accrued depreciation—January 1, 1928.
725. Other deferred assets.
    Total.

Unadjusted Debits:

726. Rents and insurance premiums paid in advance.
727. Taxes paid in advance.
728. Discount on capital stock.
729. Discount on funded debt.
730. Property abandoned chargeable to operating expenses.
731. Other unadjusted debts.
732. *Securities issued or assumed—Unpledged. (In short column only.)
733. *Securities issued or assumed—Pledged. (In short column only.)
    Total.

Liability Side

Stock:

751. Capital stock.
    Book liability. (In short column.)
    *Held by or for carrier. (In short column.)
    Actually outstanding at date. (In long column.)
752. Stock liability for conversion.
753. Premium on capital stock.
    Total.

Governmental Grants:

754. Grants in aid of construction.

Long Term Debt:

755. Funded debt unmatured.
    Book liability. (In short column.)
    *Held by or for carrier. (In short column.)
    Actually outstanding at date. (In long column.)
756. Receiver's certificates.

Form of Balance Sheet—Continued

Present

Liability Side

Long Term Debt:—Continued

757. Non-negotiable debt to affiliated companies:
   (a) Notes.
   (b) Open accounts.
   Total.

Current Liabilities:

758. Loans and bills payable.
759. Traffic and car-service balances payable.
760. Audited accounts and wages payable.
761. Miscellaneous accounts payable.
762. Interest matured unpaid.
763. Dividends matured unpaid.
764. Funded debt matured unpaid.
765. Unmatured dividends declared.
766. Unmatured interest accrued.
767. Unmatured rents accrued.
768. Other current liabilities.
   Total.

Deferred Liabilities:

769. Liability for provident funds.
770. Other deferred liabilities.
   Total.

Unadjusted Credits:

771. Tax Liability.
772. Premium on funded debt.
773. Insurance and casualty reserves.
774. Operating reserves.
775. Accrued depreciation—Road.
776. Accrued depreciation — Equipment.
777. Accrued depreciation—Miscellaneous physical property.
778. Other unadjusted credits.
   Total.

Corporate Surplus:

779. Additions to property through income and surplus.
780. Funded debt retired through income and surplus.
781. Sinking fund reserves.
782. Miscellaneous fund reserves.
783. Appropriated surplus not specifically invested.
   Total appropriated surplus.
784. Profit and loss—Balance.
   Total corporate surplus.

Proposed

Liability Side

Long Term Debt:—Continued

757. Non-negotiable debt to affiliated companies:
   (a) Notes.
   (b) Open accounts.
   (c) Interest accrued.
   Total.
758. Road leased from others.

Current Liabilities:

759. Loans and bills payable.
760. Traffic and car-service—Credit balance.
761. Audited accounts and wages payable.
762. Miscellaneous accounts payable.
763. Interest matured unpaid.
764. Dividends matured unpaid.
765. Funded debt matured unpaid.
766. Unmatured dividends declared.
767. Unmatured interest accrued.
768. Unmatured rents accrued.
769. Other current liabilities.
   Total.

Deferred Liabilities:

770. Liability for provident funds.
771. Other deferred liabilities.
   Total.

Unadjusted Credits:

772. Liability for provident funds.
773. Other deferred liabilities.
   Total.
774. Insurance and casualty reserves.
775. Equalization reserves.
776. Accrued depreciation—Road.
777. Accrued depreciation — Equipment.
778. Accrued depreciation—Miscellaneous physical property.
779. Other unadjusted credits.
   Total.

Corporate Surplus:

780. Additions to property through income and surplus.
781. Funded debt retired through income and surplus.
782. Donation reserves.
783. Debt retirement reserves.
784. Miscellaneous reserves.
   Total appropriated surplus.
785. Profit and loss—Balance.
   Total corporate surplus.

*Nominally issued and nominally outstanding.

POSITION AND VIEWS OF THE ACCOUNTING OFFICERS' COMMITTEE REGARDING DEPRECIATION ORDER NO. 15100

During the course of the conference work between the Bureau of Accounts and the carriers' committee appointed by the Railway Accounting Officers' Association to confer with the representatives of the Commission regarding the proposed revision of the accounting rules, the issuance by the Commission under date of November 2, 1926, of its decision with reference to depreciation charges made it necessary that the further consideration of proposed changes in the accounting classifications recognize the requirements of the depreciation order. As previously explained, the Accounting Officers' committee advised the representatives of the Commission of its position, expressed by resolution, that its co-operation with the Commission in the tentative revision of the accounting classifications should not be construed as an acceptance or approval by the carriers' committee of the principles contained in the Commission's Order 15100, and shall not prejudice the right of any carrier individually or the carriers collectively to contest any of the provisions of that order. During the conferences which followed, the depreciation order was reviewed and discussed in an endeavor to develop the underlying principles, to ascertain the reason or cause for certain findings of the Commission in the order, and to obtain illustrations concerning the administration of the order by the Commission through the medium of the accounting rules. Regarding the depreciation order, the committee of the Accounting Officers' Association reported to the committee on general accounts of that association as follows, under date of April 23, 1927: (Printed in Bulletin No. 113, Railway Accounting Officers' Association).

We conclude that there are four outstanding items, or provisions, in Order 15100 which, from an accounting standpoint, present major difficulties in complying with the Order:

1. Track material.
2. Extraordinary repairs.
3. Restatement of Investment in Road and Equipment by primary accounts.
4. Setting up in the Balance Sheet, in accordance with the principles set forth in the Order, the amount of past accrued depreciation.

1. Track Material.—Under the Order each rail length, cross-tie, frog, switch point, rail joint, tie plate, track bolt, track spike, yard of ballast, etc., is a separate unit of property and when replaced must be written out of the Investment Account at its cost by a charge to Depreciation Reserve. The new unit installed must be charged to Road and Equipment at its cost; the labor of removing and replacing is to be charged to Operating Expenses. The Primary Accounts in Operating Expenses for track material items, i. e., ties, rails, other track material and ballast, are eliminated, the only charge to Expenses being Depreciation, at rates to be determined, and the labor of applying. This will make necessary detailed reports, by Valuation Sections, of all items of track material removed from the track, the cost of this material when laid, and the salvage value of the released material; also the quantity of each item laid, whether new or second-hand and its cost. All replacements and retirement of these items are to be written out of and into the R. & E. Account and will not affect Operating Expenses. This means considerable increase in clerical force on the Divisions to list, check,

price and assemble the charges and credits. A completion report by Valuation Sections will be required, say each six months or each year. This latter term has not been decided and monthly Completion Reports may be required.

The Sub-Committee on Revision some time ago recommended that the track material accounts, together with accounts for grading and track laying and surfacing—be combined in one R. & E. Account to be called Roadway and Track. (See Item 3, page 11.) This would require an amendment to the Order and would eliminate the entire track structure from the Depreciable Accounts. Under this rule all repairs and renewals would be handled as heretofore and depreciation rates would not be set up for Roadway and Track. As an economical and efficient method of accounting for repairs and renewals of roadway and track this method is recommended, particularly as it blends more readily with budget systems and the equalization accounts. The depreciation method is cumbersome and unduly expensive.

2. Extraordinary Repairs.—The procedure suggested in the Order for this item is based upon the theory that as heavy repairs tend to lengthen the service life, such repairs should be spread over the service life through depreciation charges, instead of being charged when made to Operating Expenses. The result will be a "dead line" of charges to Operating Expenses through Depreciation regardless of the actual work done and the expenses therefore for maintenance will have no relation to the earnings. In a year of large earnings the Government will take one-half of the profits under the recapture clause while in poor years the maintenance expense will not change and a possible deficit may result. In its report accompanying the Order the Commission states that without this method of accounting "reserves will be created that will serve no useful purpose." It is submitted this is a fallacy, as the reserve from depreciation charges to take care of ultimate retirement of the property will not be affected by this rule but there will be added to the reserve a sum to take care of extraordinary repairs which will be idle until the repairs are made leaving the 'retirement' Depreciation Reserve intact. The accounts should exhibit the facts and if extraordinary repairs are made, the account should show it with a proper explanation. The principal difficulty of the Bureau of Accounts is the determination of what constitutes extraordinary repairs and a percentage of the cost has been suggested which appears to be pure speculation. In the case of freight cars, if the cost of the repair is in excess of, say, 30 per cent of the reproduction cost of the car, such excess must be charged to Depreciation Reserve instead of to Operating Expenses. This same rule will apply to locomotives, passenger cars, work cars, stations, bridges and all other units of carrier property classified as depreciable. It is submitted that the Commission has confused extraordinary repairs with the ordinary classified repairs which normally occur in cycles throughout the life of any unit of property. Railroads require certain standards of condition, which are maintained:

(a) Currently, through the medium of so-called "current" or "spot" repairs.

(b) Through the medium of general or classified repairs.

Both are required in transportation service to maintain the standard condition specified. Extraordinary repairs should only be construed to comprehend repairs of unusual character, exceptionally costly, such as restoration or reconstruction occasioned by the elements, i. e., floods, hurricanes, storms, etc.

3. Restatement of Road and Equipment—Primary Accounts. For the purpose of this Order the carrier is required to state the depreciable primary accounts on the basis of valuation inventory plus additions and betterments and minus retirements, since valuation date, as per finding No. 8 in the Report. The total amount of depreciable accounts so stated shall be

deducted from the R. & E. account as it appears in the Company's books and the differences, plus or minus, shall be carried as an unadjusted investment. This "unadjusted investment" will represent grading, track laying and surfacing, general expenditures and land. Apparently this is in direct opposition to the principle that the land shall be stated at its present value and it is further emphasized in the second proviso of finding No. 8 which requires that if the unadjusted amount shall be a minus quantity the primary accounts shall be reduced proportionately to absorb such minus quantity. This, however, is only to be done after approval by the Commission. The Order on page IX provides that carriers may extend the distribution to all other primary accounts so as to state the Valuation Inventory figures for grading, track laying and surfacing, etc., but it specifically excludes the land from this option. The theory underlying this is that the Investment Account shall state the cost and not the value. The question then is immediately raised upon what figure will the carriers be permitted to earn a return and also which figure will be used in stating the "recapture investment."

4. Setting Up in the Balance Sheet the Amount of Past Accrued Depreciation.—Each carrier is required by the Order to set up on its balance sheet, January 1, 1928, as a charge in a suspense account on the asset side, and concurrently as a credit to depreciation reserve on the liability side, amounts estimated to represent the expired life of the tangible elements which are classed as depreciable, the amount being ascertained in the same manner as current depreciation is to be accrued on and after January 1, 1928.

If the guess for current depreciation is proven to be incorrect, then the amount set up as representing amount accrued to January 1, 1928, will also be incorrect.

This goes to the heart of the railroad situation. It affects the investment account and the balance sheet and would probably if carried out as proposed in the Order wipe out the surplus of the carriers as a whole.

There is a most radical departure from present methods of accounting for maintenance and upkeep of the property, in that for track structure the cost of the replacement materials—ties, rails, ballast, and other track material—will not be charged to Operating Expenses but to Investment Account; and representative quantities at costs or estimated amounts, must be retired from Investment Account and charged to the Depreciation Reserve. This is evidently for the purpose of removing any elasticity in maintenance accounts and depriving the Management of any right to exercise discretion as to the amount that shall be placed in the Income Account as a charge for the upkeep of the property. It is vital in this respect, in that it does not permit the carriers to include in their current operating accounts expenditures ordinarily charged to operation for rails, ties and other track material replaced in order to keep the property in safe condition and assure efficient and economical operation. Such expenditures as made would under the Order be charged to Investment Account and only the amount determined upon as a charge through depreciation would be made to operating expenses for account of material entering into upkeep of roadway and track. It is clear that the purpose of this is to take away the discretion now resting with the Management as to what they shall charge out in a good year and what they shall spend in a lean year, which is an unrestricted exercise of management judgment that exists in every other business.

Again, like in the scaling down of value of tangible elements, it works only one way for the Commission; the plan will take the money away under recapture in the year of heavy traffic and restore nothing in the year of light traffic.

This is further complicated by what is styled "Extraordinary Repairs," introduced into the accounting to reduce maintenance expenses and prevent the Management from making charges to Operation in prosperous years for rehabilitating its property. So far as we have been able to develop, there is

no sound economic basis for the "extraordinary repairs" feature as dealt with in this Order.

The Order, and, so far as we have been able to ascertain, the method of putting it into effect, would result in a radical change in the Balance Sheet, in the Operating Expenses and Income Account of the carriers. It would effectively destroy any comparisons, would render uncertain the rate base for transportation charges and open up the whole railroad question, not only as to the validity of investment but would create a situation whereby, for a number of years at least, the carriers would find it very difficult to defend any attack on the present freight rates unless they resorted to what the law absolutely prohibits, i. e., keeping two sets of books and accounts.

Our study indicates that the theory is fundamentally unsound as to valuation and unsound as to accounting for maintenance and upkeep of the property. It has been made very clear to the representatives of the Commission that in our opinion, the purpose of the Transportation Act could be met in a practical manner without the radical, and, what we believe, the harmful procedure as set forth in Order No. 15100 and the tentative rules for application so far submitted.

The following plan of procedure has been presented to the representatives of the Commission and urged for their consideration:

(A) Any reserve which may be created should be through charges to Operating Expenses representing an amount sufficient to extinguish the investment of the carrier in the selected facility when it is retired.

(B) That the carriers be permitted to continue present practice with respect to depreciation of equipment, subject to such minor adjustments as the Commission may find necessary in individual cases.

(C) That the carriers be permitted to continue charging operating expenses direct with labor and material used in repairing and maintaining roadway and structures. That all structures or units of property retired shall be written out of investment and charged to Operating Expenses. That commencing with January 1, 1928, all structures or units of property installed shall be charged to Investment in Road. A permanent record will be made of each unit so installed showing the date put into operation, the cost and the best estimate as to life, which will be used as a basis for creating a reserve for its retirement through charges to current operating expenses.

This will afford a basis of actual units of property, the actual cost and the only guess will be the service life. It will afford an opportunity to secure facts and develop from these facts and experience what does take place. This plan would eliminate the setting up of the past accrued depreciation as a suspense item on the balance sheet, would remove the objectionable and expensive method of accounting for track material and for extraordinary repairs as provided in the Order.

Appreciating the desire of the Director, Bureau of Accounts, Interstate Commerce Commission, that the Sub-committee co-operate in incorporating in the revised classifications accounting rules for the administration of Order No. 15100, and, being assured by the representatives of the Commission that the co-operation of the Sub-committee in the tentative revision of the accounting classifications hereafter issued by the Commission, directly or through the R.A.O.A., shall not be construed as an acceptance or approval by the Sub-committee, or any member thereof, of the principles contained in the Commission's Order No. 15100, and shall not prejudice the right of any carrier individually or the carriers collectively to contest any of the provisions of said Depreciation Order, qualifications fully set forth in the resolution, quoted previously, the Sub-committee entered upon the consideration of the tentative revision of the accounting rules to incorporate therein the changes necessary by reason of Order No. 15100 and for other reasons hereinafter set forth.

Appendix G

(7) PLANS, METHODS AND FORMS FOR GATHERING AND RECORDING DATA FOR KEEPING UP-TO-DATE THE PHYSICAL AND VALUATION RECORDS OF THE PROPERTY OF RAILWAYS

C. C. Haire, Chairman, Sub-Committee; E. Y. Allen, B. A. Bertenshaw, A. M. Blanchard, E. S. Butler, J. W. Dansey, H. E. Hale, W. A. Hill.

The Committee's report for this year consists of a review of the previous two progress reports, and, in addition, report is submitted, for the first time, on certain features of the assignment not previously covered.

New problems are constantly developing in connection with this subject, due to systematizing present methods and contemplated changes in the science of accounting; also, consideration must be given to the proposed Classification of Accounts and Depreciation Order, Docket No. 15100, of the Interstate Commerce Commission. It has become manifest that the Committee's assignment must be kept alive indefinitely, or until conditions are more stabilized in valuation and accounting requirements.

The Committee desires to make a final report on certain phases of the assignment, for publication in the Manual, part of which have been published heretofore in the Proceedings of the Association; also it submits additional material for consideration at this time and recommends that it be included in the Manual.

The Committee's report covers the following subjects:

1. Definition of Terms.
2. Organization for Collecting, Compiling, Recording and Filing
3. Forms for Recording Changes in Physical Property.
   - (a) Field Survey Note Books
   - (b) Final Construction Record
   - (c) Engineer's Diary
   - (d) Record of Side Tracks
   - (e) Structural Record—Buildings
   - (f) Roadway Machine Record
   - (g) Shop Machine Record
   - (h) Equipment Index—Record of Equipment Changes
   - (i) Structural Record—Bridges
   - (j) Rail Chart
   - (k) Record of Ballast Changes—Ballast Chart
   - (l) Record of Rail in Main Track and Record of Heat Numbers
4. Forms for Analysis of Expenditures and Comparison With Actual Changes in Physical Property.
   - (a) "Consolidation Sheet" for Analysis of Expenditures
   - (b) Cost of Property Retired
   - (c) Cost Data Analysis

5. Mandatory Forms Required by Federal Regulations.
   (a) A.F.E. Form (Authority for Expenditure)
   (b) Detailed Estimate Sheet
   (c) Record of Property Changes
6. List of Units of Railway Property.
7. Recommended Practice to Follow, in Reporting the Construction Cost and Physical Characteristics of a New Line or Extension.

(1) DEFINITIONS OF TERMS

(Definitions of certain accounting terms have been briefly stated herein; for more complete definitions reference should be made to the I.C.C. Accounting Classification and other authorities.)

Addition.—A structure, facility, equipment or other property unit added to those in service.

Accounts.—Written and delineated statements of financial or pecuniary transactions of a carrier.

Accounting Adjustment.—A re-stating of an amount in the accounts of a railway to another account or accounts.

Accounting Report.—A statement compiled and published by the Interstate Commerce Commission, showing the financial history of a railway and a re-statement of its accounts as of a stated date of valuation.

Authority for Expenditure.—An authorization made in writing by an executive officer of the railway management giving permission to create, purchase, change or retire certain physical property, setting forth in detail the description, reasons, costs and financial effect of the project.

Betterment.—Improvement of an existing facility through the substitution of superior parts for inferior parts retired.

Budget.—A statement giving recommended projects and their estimated cost to be undertaken for a definite period or a forecast of income or expenditures for a given period.

Carrier (adj.).—Physical property of a railway and other assets used in or held for transportation service.

Carrier (noun).—A corporate company, owner of physical property and other assets used in or held for transportation service.

Charge.—An entry in accounting; setting down or debiting an item or sum to some account.

Chart.—A delineation or statement in graphical form.

Cost.—The outlay incurred in acquiring, creating, operating or maintaining a property, including the money value of the services rendered and other considerations involved.

Credit.—A negative charge.

Depreciation.—Loss of physical worth, due to age, use, inadequacy, obsolescence, depletion and other similar causes.

Equipment.—Rolling stock, floating equipment and highway vehicles devoted to common carrier's service.

Equipment Completion Report.—A record prescribed by Valuation Order No. 3, Second Revised Issue, showing for equipment detailed information with respect to additional units placed in service, withdrawals therefrom, additions and betterments thereto, and the costs chargeable and creditable to the accounts of the carrier as a result thereof.

Facility.—A portion of the property capable of rendering a specific service.

Federal Valuation.—A mandate of Congress designated as Section 19a of the Interstate Commerce Act requiring the Commission to investigate, ascertain and report the value of all the property owned or used by every common carrier subject to the provisions of the Interstate Commerce Act.

Final Valuation.—The value found by the Interstate Commerce Commission as the Rate Base in pursuance of its work under the Valuation Act of 1913.

Fixed Property.—Property of immovable nature or incapable of a change in location without reconstruction, either in whole or in part; property which may not be used except in a fixed location.

Forms.—A prepared medium upon which to transcribe records and accounts, such as ruled sheets for books, ledgers and statements.

Gross Charge.—A sum on the debit side, representing the entire amount or total of the charges resulting from any transactions before credits are deducted.

Gross Credit.—A sum representing the entire amount or total of credits resulting from any transactions before debits are deducted.

Gross Cost.—The total outlay incurred in any transaction, including the money value of services rendered and other considerations involved, before credits are deducted.

Investment Account.—The account in the transportation industry to which is charged or credited amounts affecting changes in the cost of the railway; the ledger value of the railway.

Income Account.—The account showing the net amount of money received, or the deficit for services rendered by a railway, including returns from investments. Operating Revenues and other sources of income are credit accounts and Operating Expenses, Taxes and other similar costs are debit accounts.

Interstate Commerce Commission's Engineering Report.—A statement compiled and published by the Interstate Commerce Commission, showing the physical property of a railway, classified according to ownership and use (except "Land") by units, unit prices and totals, purporting to give the cost of reproducing a railway at a given date of valuation; also, showing cost of reproduction with depreciation deducted.

Inventory (noun).—Records showing material, supplies and other assets of a railway at end of any given period.

Inventory (verb).—The act of counting and recording material, supplies or other property of a railway.

Investment in Road and Equipment.—The account in transportation accounting to which the cost of all changes in carrier property is debited or credited. (See Investment Account.)

Joint Facility.—Railway property which two or more carriers either jointly own, maintain or operate by formal agreement.

Labor—Cost of.—The amount paid for labor performed by the carrier's own employees.

Land Report.—A statement compiled and published by the Interstate Commerce Commission, showing a detail of the real estate owned by a railway and the value reported by the Commission as of a stated date, indicating that property used for transportation purposes and otherwise.

Ledger Value.—The value at which the property is carried in the Property Investment Account of the carrier.

Material—Cost of.—The amount paid for the purchase, inspection, transportation and loading of material, plus a proportion of the store expense.

Net Charge.—A sum on the debit side, representing the entire amount or total of the charges resulting from any transactions after credits are deducted.

Net Credit.—A sum representing the entire amount or total of the credits resulting from any transactions after debits are deducted.

Non-Carrier.—Physical property and other assets of a railway neither used nor held for transportation service.

Operating Expenses.—The expenditures of a railway for furnishing transportation service, including expenditures for maintaining the carrier property used in such service.

Operating Expenses—M. of W. and S.—The expenditures of a railway for maintenance, repairs and depreciation of fixed improvements devoted to operations except shop and power plant machinery.

Operating Expenses—Maintenance of Equipment.—The expenditures of a railway for maintenance, repairs and depreciation of equipment, shop and power plant machinery.

Operating Expenses—Transportation for Investment—Cr.—The amount representing the cost to a railway for transporting men, materials and equipment for construction work, which is a credit to Operating Expenses and a debit to the Investment Account.

Operating Expenses—Water Line.—The expenditures of a railway for transporting persons and freight by water lines, including water terminal expenses.

Operating Expenses—Transportation Rail Line.—The expenditures for train service by a railway for transporting persons and freight including station, yard and terminal service.

Operating Expenses—General.—The expenditures of a railway for general administration, accounting, law, real estate, claim, relief, pensions and expense not directly assignable to other phases of railway operating expenses.

Operating Expenses—Traffic.—The expenditures of a railway for advertising, soliciting and securing traffic, including the publication and distribution of tariffs.

Operating Expenses—Miscellaneous Operations.—The expenditures of a railway for dining cars, hotels, restaurants, grain elevators, stock yards and other miscellaneous operations.

Original Cost to Date.—Cost of original construction, plus all charges against Capital, under proper accounting principles, for expenditures incurred thereafter, and minus all proper credits to Capital for the cost of property which has been disposed of, or otherwise retired.

Payroll (noun).—A list of persons or employees showing amount earned for services performed.

Payroll (adj.).—Expenditures in railway accounts resulting from the cost of labor.

Plat.—A portion of a map designed to show some part with particularity.

Primary Account.—A mandatory, designated subdivision of a general account in railway accounting required by the Interstate Commerce Commission.

Profile.—A longitudinal section through a work or section of country to show the elevations and depressions.

Profit and Loss.—A subdivision of railway accounts in which to record transactions which result in gains and losses from common carrier operations.

Project.—A scheme or plan for creating or changing physical property.

Property Change.—Any change in the physical property.

Property Replaced.—An accounting unit of property which is taken out of service and replaced with another.

Physical Records.—Written and delineated information showing the location, extent, size, history and other essential details of the property of a railroad.

Records.—Facts or statements written, delineated or otherwise transcribed to perpetuate a knowledge of acts and events pertaining to the transportation industry.

Replacement.—Property put in place of some previously existing facility, to serve a like purpose.

Retirement.—Property which for any reason is taken out of the service for which it was created or installed; fixed property moved from one valuation section to another.

Retirement Entry.—An amount credited to the Investment Account as the ledger value for a unit of property taken out of transportation service.

Roadway Completion Report.—A report required by Interstate Commerce Commission, Valuation Order No. 3, Second Revised Issue, to show for each project the detailed changes in fixed physical property by units and costs.

Salvage.—Material or value recovered from property retired or from property after use as a construction aid.

Transportation Service.—(As used in Investment in Road and Equipment accounting.) The date any property change is placed in or removed from transportation service.

Tentative Valuation.—A tentative draft of a report by the Interstate Commerce Commission to Congress on each common carrier, made pursuant to Section 19a of the Interstate Commerce Act, setting forth the Commission's tentative findings of fact, as specified by law, and its findings of the value of property owned or used by such common carrier for common carrier purposes, and certain other information prescribed by law on its non-carrier property, served upon each common carrier owning or using any part of such common carrier property, and upon certain other parties specified by law, as a basis for receiving testimony and hearing argument from all interested parties concerning a final report by the Commission to Congress of its findings of such facts and values for such common carrier.

Unit Cost.—The cost of any selected unit of property.

Unit of Property.—The amount or quantity of any class of physical property adopted as a standard of measurement for other amounts or quantities of the same kind.

Valuation Order No. 3.—An Order of the Interstate Commerce Commission to enable it to comply with the provisions of paragraph (f) Section 19a of the Interstate Commerce Act. It prescribes a uniform system for recording and reporting changes in the physical property of every common carrier subject to the act to regulate commerce.

Voucher.—A record of payment used in the railway industry that indicates in detail and by proof the entire history of the transaction.

Valuation Records.—Physical records of a nature to show the money value of the component parts of railroad property and evidence of methods and data used in determining such costs and value.

(2) ORGANIZATION FOR COLLECTING, COMPILING RECORDING AND FILING

In recommending an organization for collecting, compiling, recording and filing, consideration has been given to the carriers' own requirements and to the regulations of the Interstate Commerce Commission's Valuation Order No. 3 and the regulations of various states.

The collecting, compiling, recording and filing of data for keeping up to date the physical and valuation records is so closely allied to the railways' accounting methods that it is considered in the interest of efficiency and economy that all the requirements can well be combined.

For years many carriers maintained some form of organization which recorded currently and reported to the Interstate Commerce Commission annual expenditures to Investment in Road and Equipment, and requirements of some few states necessitated reports from a few carriers as to changes in physical property, so that many railroads had some scheme to collect and record information for all accounting purposes and for their own internal needs.

The issuance of Valuation Order No. 3 has brought to the front the need of greater refinement and elaboration of accounting for Investment in

Road and Equipment expenditures, as it is mandatory to set up property changes in detail on prescribed form and to submit summaries of the result, annually and semi-annually.

The procurement of information as to physical changes to the property of railways naturally requires an orderly and systematic method of procedure. The mandatory requirements outlined briefly certain procedure, but it is insufficient to meet all the needs of the carriers for their physical records and accounting work.

The methods that are considered best by the Committee for gathering and recording data can be summarized as follows:

(1) All physical changes to property to be included in an annual budget, excepting special and emergency cases, which it may be necessary to handle, or the condition of expenditures and revenue may permit of subsequent changes to the budget, which can be added thereto.

(2) All changes in physical property, except ordinary repairs to be carried out under an "Authority for Expenditure."

(3) "Authority for Expenditure" estimates should be prepared in the same general form as required to record the expenditures on roadway completion reports, so that direct comparison can be made and so that the estimates may serve as a guide to those who handle construction accounting.

(4) Expenditures to be recorded, tentatively distributed and summarized under the direction of the organization responsible for collecting, compiling, recording and filing physical data, and the system of records and accounts required for Investment in Road and Equipment and other mandatory regulations of states and the Interstate Commerce Commission.

(5) Physical changes to be inventoried and recorded by proper units under the direction of the organization mentioned immediately above.

(6) The analysis of charges and comparison of inventory of physical property, perpetuated to compile final accounting records and records of physical changes required for carriers' internal use and mandatory regulations to be handled under the direction of the organization mentioned above.

The record of physical changes to property is needed in the operation and maintenance of the carriers and it is important to keep up to date maps and profiles and to have complete records of this nature to show what changes were made. In the administration and handling of an Engineering Department, correct station maps, profiles, right-of-way and alinement maps and records, etc., are of importance and these records must be maintained to a high state of perfection at all times.

The Engineering Department is required to continually originate estimates for the purpose of improving and maintaining the property. Estimates cannot be made intelligently and correctly unless there are physical data in some form to show the characteristics of the property. This must be complete information of all local conditions, costs, topography of country, construction difficulties encountered, geological conditions, etc. Much of this information is interwoven with accounting records, such as the cost of performing work, but the majority of it should come from the construc-

tion engineers who should record currently, by diaries and other records, in an historical manner, the progress of the work and all difficulties and conditions encountered.

After original construction of a railroad, all the records in connection therewith should be carefully preserved, but it is evidently of greater importance, as improvements are made in a plant, that each engineer who handles any construction or changes in connection with maintenance, should make a record of changes, giving a complete outline in the nature of an engineering report of the new units added and their cost and those units that are retired. Such an engineering report should be profusely illustrated with drawings, plans, sketches, photographs, etc.

In constructing new lines and extensions, or additions to existing property, engineers ordinarily keep notes and memoranda of a varied nature; they must, of necessity, prepare progress profiles, cross-section sheets, sketches, field notes, make working drawings of any changes and, in a varied way, a complete history of the project reported, and it is obvious that the scattered notes, memoranda and data be collected in a uniform manner, in one record, so that this information can be conveniently reported and filed.

This Committee is of the opinion that ordinarily no more time or work is required to record all notes and construction data of physical changes in one set of records of uniform size and manner than to prepare the data in any other form.

It is considered that information of this kind can be easily collected and filed so that for all future time it will be readily accessible as a history and as a record of any construction work or physical change in the property.

The collecting, compiling, recording and filing of the physical data is further made necessary by the present-day refinement of accounting and the needs of reporting cost of construction in a uniform manner. Roadway Completion Reports require that the cost of construction be reported by using standardized units and reporting the cost of units of property added and property retired. It is only from the correct record of physical changes that this information can be called; therefore the Committee calls attention to the obvious necessity of combining the two functions under one organization and one head.

All other records in connection with the State and mandatory regulations of the Interstate Commerce Commission revolve around a physical record as described above and cost reported on Roadway Completion Reports, and the collection of the information in a summary that is required either semi-annually or annually is a mere matter of detail and office routine.

The accounting requirements, as promulgated in the Classification of Investment in Road and Equipment, has stipulated, for many years, certain procedure in recording cost of construction work, but no method is specified in detail as to how to arrive at the information; consequently the accounting for the cost of construction by railways has not been uniform nor regular.

The cost of construction work cannot be correctly recorded and the requirements of the Classification of Investment in Road and Equipment

cannot be carried out correctly unless based upon the construction data outlined in the foregoing. This is obvious in connection with the separation between the various primary accounts of Investment, Operating Expenses, Income, etc., as unit quantities are frequently the only basis of making a separation. Much could be said and there could be much argument as to why this is a fact.

The keeping up to date of the valuation records of railroad property, aside from the physical records, involves the question of amounts added to and retired from the Investment Account of the carriers and as such amounts are based upon construction costs and information originating with engineers and their subordinates, the Committee is of the opinion that construction cost accounting is a joint accounting and engineering function, for the following reasons:

(1) The accounting and engineering work involved in handling the collecting, compiling, recording and filing of data for the physical changes to property, as is required for carriers' own use and in the mandatory form, and the accounting for Investment in Road and Equipment projects, are inseparable.
(2) The handling of accounting in connection with construction cost and the engineering work in connection with collecting, compiling, recording and filing the physical changes to property, requires specialized employees of both engineering and accounting experience.
(3) The control of Capital Expenditures and those expenditures chargeable to Operating Expenses or Other Accounts, in connection with construction work, is a responsibility of the engineers who are in charge of the execution of work and the inseparable engineering and accounting work required, for construction expenditures must be co-ordinated with such control of expenditures.

In considering the mandatory requirements of the various regulatory bodies, both federal and state, and the carriers' own needs, it is obvious that it is both efficiency and economy to organize so as to satisfy all the following purposes simultaneously:

(1) Collect, compile, record and file data for carriers' own use, such as:
    (a) Construction cost data and physical records.
    (b) Investment in plant for tax return purposes.
    (c) Investment in plant for insurance schedule purposes.
    (d) Participation in joint ownership.
    (e) Investment in joint facilities.
    (f) Compile indices of price trend for equating original cost to date, to cost of reproduction for rate purposes.
(2) Accounting for Investment in Road and Equipment expenditures.
(3) Records and accounts prescribed by Valuation Order No. 3 and Supplements No. 1 and No. 2 thereto.
(4) To comply with the requirements of Valuation Order No. 23, which requires the maintaining up to date of certain valuation maps.
(5) To comply with State laws and requirements of Public Service Commissions.

To comply with governmental regulations it is necessary to carry out the suggestions made in the preceding paragraph. It is necessary, further, that the data be compiled concurrently with the progress of the work; therefore the carriers' own interests will also be served by making the reports within the time limits prescribed by the legal requirements.

The failure of many railways to meet the time limit imposed on them in the submission of their reports to governmental bodies can be traced directly to division of responsibility existing between various departments and the fact that the engineering work and the accounting work is not combined in handling the various features directly or indirectly connected with the real objective of preparing final returns for the reports.

The most feasible and proper organization to function so as to obtain all the results can best be secured by a separate bureau or department, properly correlated to the Accounting, Operating and Engineering Department. A separate bureau or department, functioning in a dual manner, eliminates any division of responsibility and duplication of work performed, with its consequent heavy cost to the railway. Duplication of work often exists in railway organizations, instituted under the cloak of department needs and so-called departmental responsibility. However, from the standpoint of efficiency and economy, such duplication is in the last analysis superfluous.

Centralization of authority, including centralization of working forces, answers the requirements of expediency and economy as a close co-operation between a bureau and other departments that can be maintained. Efficiency is, however, a direct contribution of the personnel.

A single acting department or bureau to handle all functions is required to efficiently administer to the handling of the mandatory regulations and to maintain correct accounting. The interest of any department should not dominate nor influence the proper handling of the various records and accounts, and the mandatory systems of records and accounts cannot be successfully maintained unless handled in an independent manner from other organizations, not prejudiced in any way by other department needs.

The handling of this branch of engineering and accounting work being a specialized field and having important functions should, therefore, in the opinion of the Committee, be an independent department or bureau under the direction of an experienced engineer or accounting officer. The importance of reliable accounting and the interest engineers should have in cost data, accounting records and accounts in general was called forcibly to the attention of the members of the American Railway Engineering Association by Past-President Lee, in his address before the March, 1924, Convention, as follows:

> "Railroad Accounts are valuable as a record of past performance and existing status, but a more important element of their value is in the use of these records as a basis for decisions as to future practice and performance. Necessarily these accounts are kept so as in a way to resemble a code. All railroad officers should have some general knowledge of railroad accounts. Many of the members of our Association have such a knowledge, but every member of the Association should make it his business to familiarize

himself thoroughly with railroad accounting, both in principle and practice, in order to be able to decide for himself information constantly necessary.

"If I may hand on a word of advice to our younger members, so full of brains and ambition and enthusiasm, I would be inclined to say, as everyday work, do the job in hand to the best of your ability; as special work, master railroad accounting in principle and practice; and, as a general interest, study the psychology of your fellowmen."

The Committee's recommendations for a separate bureau or department form of organization for collecting, compiling, recording and filing data are based upon the following conclusions:

(1) The collecting, recording, compiling and filing data and keeping up to date the physical and valuation records of the property of railways is essentially the responsibility of both accounting and engineering organizations, and,
(2) Some one individual should be made responsible for the handling of the mandatory regulations of the Federal and State Commissions and for collecting and compiling physical data, as well as to handle all accounting features.
(3) Accounting features should be inclusive of accounting for Investment in Road and Equipment.
(4) That with such departmental or bureau organization, all requirements of State Commissions, Federal Commissions, tax bodies, etc., can be combined and one set of records and accounts used for all purposes.
(5) That the proper control of Capital Expenditures and construction costs is essential to scientific management, and this can be best effected by a joint bureau or departmental form of organization, removed from influences or prejudice of any other department's own needs.

(3) FORMS FOR RECORDING CHANGES IN PHYSICAL PROPERTY

(a) Field Survey Note Books

Records of this character consist of Transit note book, Level note book, Topography note book and Miscellaneous note book, and the Committee recommends the forms shown as sample pages, marked Exhibits 1, 2, 3 and 4.

All of the above note books must be of a size convenient for handling in the field, for filing in the office, and at the same time be large enough to permit the gathering of data in sufficient detail to be readily transcribed to plans or other forms, either by the maker of the notes or by others. The sample pages shown in the exhibits are the sizes and designs in most general use and seem to answer the purposes of engineers in general.

The paper should be of good quality and the rulings of fast colors in order to be proof against adverse weather and other conditions to which they will be subjected in the field.

Books may be secured either in bound form containing sixty to eighty pages each, or in loose leaf form with various types of fastenings. There are advantages and disadvantages in both of these forms.

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EXHIBIT I

		(Left Page)			

		(Right Page)			EXHIBIT 2

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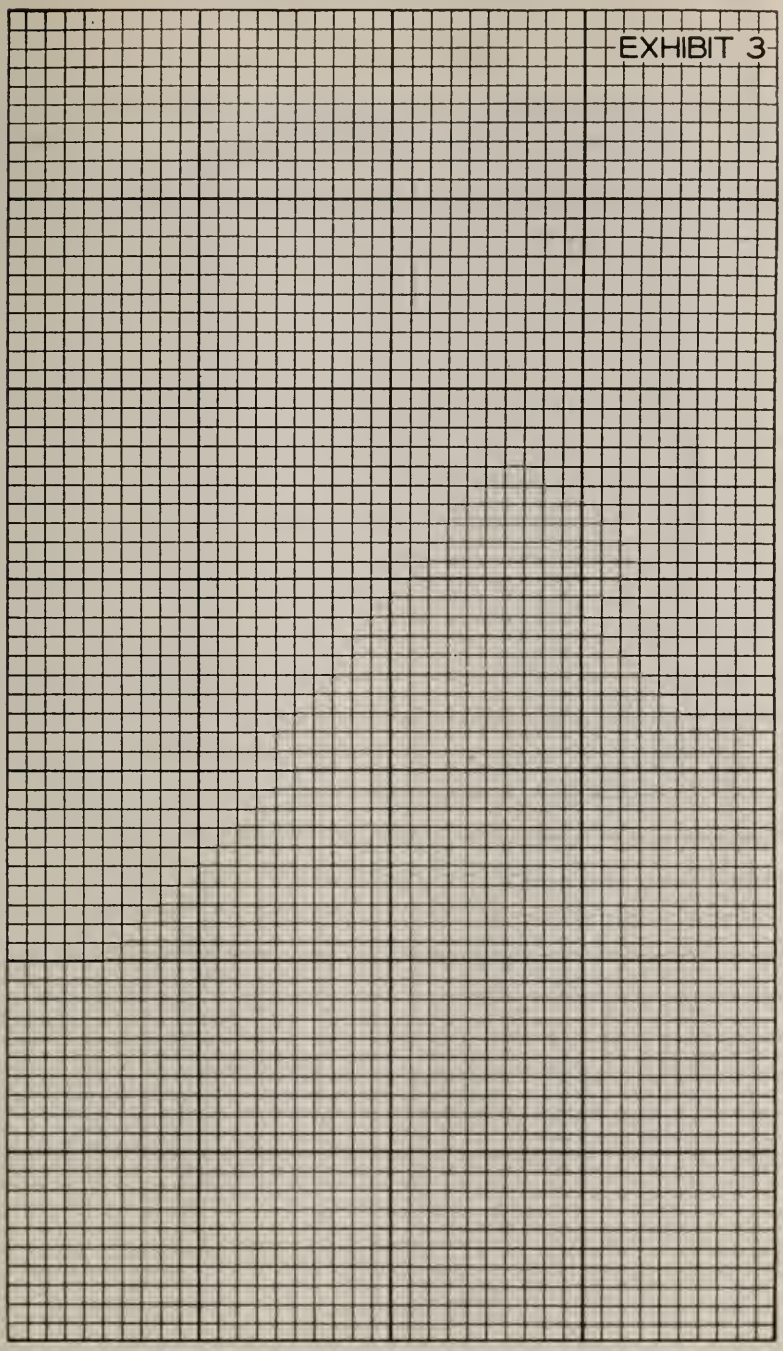

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STATION	ALINE	GRADIENT	ELEV	GRADE	CUBIC YARDS		REMARKS
					EXCAV.	EMBANK.	

(RIGHT PAGE)

EXHIBIT 4

With bound books only one man can use the same book or set of notes at a time. A book containing certain notes may be desired for use by both field and office forces at the same time, with the result that one or the other is delayed or seriously inconvenienced; also an entire book containing notes, difficult or absolutely impossible to replace, may be lost.

With the loose leaf form, one set of men may make the field notes and either mail or deliver the loose leaves containing them to the office to be transcribed, which results in speedy handling of the work and eliminates the first-mentioned objection to the bound book.

There is some possibility, with most of the loose leaf forms now on the market, of leaves tearing out or otherwise escaping from the binder and becoming lost. It will readily be seen that this might prove to be a serious loss. The same objection holds with reference to sending in loose leaves by mail unless an exact copy of all notes is kept by the field party.

There is the further possibility that, unless a copy of all notes is kept by the field party, notes may be sent in, to which reference would have to be made later in connection with field work.

The loose leaf form of note book lends itself more readily than the bound book to the use of the typewriter, blueprinting, photostating, or other forms of quickly reproducing notes where more than one copy is required; also it is more convenient for filing purposes, especially in the case of miscellaneous notes on a variety of subjects and in various locations such as small maintenance surveys covering industrial sidings, pipe and wire line crossings, individual bridge surveys, etc.

There are several types of loose leaf binders, as follows:

(a) Ring with 3, 4 or 6 rings.
(b) Spring in which the leaves are clasped in a grip, either at the left or top edges.
(c) String
(d) Covers may be both stiff or with stiff back and flexible front cover.

Loose leaves or fillers are obtainable as follows:

(a) In packets, each leaf entirely independent of the other.
(b) In pads, bound on one edge with perforations to permit leaf being easily torn off.
(c) In pads providing for duplicating of notes, the top leaf perforated while the under leaf is held in pad form.

Conclusions

(a) For continuous surveys covering many miles of line on which it is necessary for both field and office forces to work at the same time, the duplicating field book, either in bound or loose leaf type, is recommended.

(b) For miscellaneous maintenance surveys the loose leaf type is recommended; the particular kind of binder is Ring, Spring or String, to be selected by the user.

(c) Loose leaf field note or duplicate copies should be filed as a permanent record.

(b) Final Construction Records—(Exhibit 5)

In collecting, compiling, recording and filing all changes in physical property, it is essential that a "Final Construction Record" be prepared for each project to show every detail of the construction work from the start to completion. The construction record should show a chronological

Size 8½ x 11 inches — Exhibit 5

North & South Railroad
REPORT OF QUANTITIES IN COMPLETED WORK

Date..... This Report ..... Valuation Section..... A.F.E. No.....
Location..... Date of Inventory this Report.....
Description of Project:.....
.....
.....
Date Work Commenced..... Completed..... Put in Service.....

Acct. No.	Item, Description and Location	Unit	Quantity	Origin of Material

history of the project, progress of the work, difficulties encountered and all physical features illustrated, with sufficient descriptive matter to clearly portray the construction as carried out.

Too frequently the ordinary construction practice is to work up data in memorandum form, prepare sketches, mark up drawings, make cross-sections, working profiles, etc., but all this information is many times accumulated in disconnected form whereas the carrier's own needs and the mandatory requirements justify that a systematic method be followed

in compiling, recording and filing the information so that it will be available for future reference.

The final construction record should be prepared for each job or project during the progress of work, so upon completion all the data covering the physical change to the property will be available.

The record should preferably be compiled on a form of the loose-leaf type, or using a blanket form that can be adapted to all classes of work. The location and description of each phase of the work should be shown and the most logical plan is to list in detail the property change, by the standard units, under appropriate sub-divisions, by primary accounts. This record, if compiled by primary accounts, properly indexed and supplemented with maps and drawings, for each building, track, or group of tracks, bridge or similar sub-division, will answer all ordinary purposes as a record of the construction performed.

A form to meet the above described purpose has been designed and is shown as Exhibit 5. For those cases where property is retired in connection with construction work, a separate form, as shown hereafter, should be used.

Conclusions

Good engineering practice demands a final construction record showing in detail, units of property added and retired and illustrated by sketches, plans or drawings.

(c) Engineer's Diary

In connection with preliminary location and other surveys a written chronological record should be maintained in a systematic manner of the work done each day, giving all the essential facts as to forces employed, work done, weather conditions and other important information.

It is recommended that a leather bound, pocket size diary of approximate size 4½ in. by 6¾ in., with appropriate superheading to show date, location and weather conditions, be used.

(d) Record of Sidetracks—(Exhibit 11) (Present Form 1106)

One of the auxiliary records that is needed by carriers for recording changes in physical property is a record of sidetrack mileage, as well as main track mileage, changes; such a record as this is also necessary in connection with the mandatory records as are required by Federal regulations.

In connection with the Federal inventory of carriers, there were established definite side and main track lengths and a number for each sidetrack was assigned for each valuation section. Accordingly, a perpetuation of such a record is of value for main and sidetrack mileage statistics that are required annually by the Bureau of Statistics of the Interstate Commerce Commission, and for a carrier's own internal needs.

It is only by reconciling annual sidetrack mileage and the Investment Account records by "Authorities for Expenditure" that the changes in track lengths can be properly maintained; therefore the advisability, as well as

the necessity, of a record of all sidetrack changes are obvious, and the Committee's recommendations are as shown by the attached Exhibit 11, in lieu of Form 1106, that is shown on insert between pages 510-511 of the 1921 Edition of the Manual.

There is no real reason that requires the maintenance of Form 1106, whereas there are definite reasons for the use of the form recommended by the Committee; also, the Committee has been in consultation with representatives of the Bureau of Valuation of the Interstate Commerce Commission who advocate a record along the lines of the Committee's proposed form.

(e) **Structural Record—Buildings** (Exhibits 12, 13 and 14)

The Committee, in its study of general subject No. 3, "Forms for Recording Changes in Physical Property," considers that a detailed record of all buildings is essential and that all structures of this character should be numbered and changes to each building recorded by "Authorities for Expenditure."

Accordingly, the Committee recommends two forms, similar to the Exhibits 12, 13 and 14, 8½ by 11 inches in size, to be used as a card file.

(f) **Roadway Machine Record** (Exhibit 15)

In recent years the general use of motor cars and improved roadway machines of various kinds has come into vogue on steam railroads. The investment in this class of property has grown immensely and the value of each individual unit is sufficient to require an individual record of the Investment, performance and ultimate life of the unit; furthermore, this class of property depreciates rapidly, i. e., is worn out, destroyed in accidents, or otherwise, and to properly maintain the Investment Account an individual record should be kept for each unit and the Committee suggests Exhibit 15, 8½ by 14 inches in size, to be used as a loose-leaf book record.

(g) **Shop Machine Record** (Exhibit 16)

This class of property requires some detail to record its individuality and, owing to the machines being moved with some frequency from one shop location to another, the advantage of having an individual record, from an operating and engineering point of view, is obvious.

The identity of each machine must be maintained by numbers, and as they are moved or retired a record of each change should be established with definiteness.

Accordingly, the Committee recommends that a record be maintained for each machine, in accordance with Exhibit 16, 8½ by 11 inches in size, to be used as a card record.

(h) **Equipment Index—Record of Equipment Changes** (Exhibits 17, 18, 19 and 20)

In connection with other records for recording changes in physical property, the Committee has designed four forms for equipment changes, as follows:

Exhibit 17—Record of Equipment Changes, for
Account No. 53—Freight Train Cars
Account No. 54—Passenger Train Cars
Account No. 57—Work Equipment.
Exhibit 18—Record of Equipment Changes, for
Account No. 51—Steam Locomotives
Account No. 52—Other Locomotives.
Exhibit 19—Record of Equipment Changes, for
Account No. 56—Floating Equipment.
Exhibit 20—Record of Equipment Changes, for
Account No. 58—Miscellaneous Equipment.

It is considered unnecessary to use a "Record of Property Changes" for equipment, as Equipment Completion Reports contain the detail of all equipment changes in essential form, and to record these changes in any other form than the "Record of Property Changes" is an unnecessary duplication.

Exhibit 17 is an index of all items owned by a carrier of "Freight Train Cars," "Passenger Train Cars" and "Work Equipment" and the index is the equipment unit number. The index gives the original cost and the "Authorities for Expenditure" for various changes for any one unit of equipment subsequent to original acquisition.

In a manner similar to Exhibit 17, Exhibits 18, 19 and 20 are to be used for "Steam Locomotives," "Other Locomotives," "Floating Equipment" and "Miscellaneous Equipment."

The general scheme of maintaining a "Record of Property Changes" for equipment in the above described manner, has been approved in principle by the Bureau of Valuation of the Interstate Commerce Commission and the Committee recommends its use, in the interest of simplicity in handling Valuation Order No. 3, Second Revised Issue, and records of physical changes to equipment needed by the railways for their own purposes.

(i) **Structural Record—Bridges** (Exhibits 24, 25, 26 and 27)

Similar to buildings, an individual record for each bridge should be compiled, when a structure is completed, giving all the physical characteristics and sufficient details, to give a history of its construction and enough data for valuation accounting and all estimating purposes. A Bridge Record is best divided into the following sub-divisions:

Construction Report of Timber Trestles.....(Exhibit 24)
Construction Report for Wooden Boxes and Pipe Culverts .....(Exhibit 25)
Construction Report for Concrete Trestles and Arches and Boxes .....(Exhibit 26)
Construction Report for Steel Bridges.....(Exhibit 27)

The Committee recommends the use of the exhibits shown above for valuation accounting and as a physical record for bridges.

(j) **Rail Chart** (Exhibit 28)

The Committee submits a form for maintaining records of main track rail changes which occur with great frequency. The Committee's plan of handling the record contemplates that the initial record of laying rail on

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Exhibit 17

SIZE 11"x28"

NORTH & SOUTH RAILROAD

RECORD OF EQUIPMENT CHANGES

OWNED BY _____ SERIES _____

OPERATED BY _____ CLASS _____

DESCRIPTION _____

UNIT NUMBER	COST AS OF —	EQUIPMENT ACQUIRED SUBSEQUENT TO —			ADDITIONS AND BETTERMENTS														RETIREMENTS			REMARKS
		A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	
31																							
32																							
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Exhibit 21

State of .....
Valuation Section .....

NORTH & SOUTH RAILROAD
RECORD OF PROPERTY CHANGES

Account No. .....

Sheet No. ..... of ..... Sheets
Year Ended December 31, 192.....

	A.F.E. Number and Reference (1)	DATES Installed (2)	DATES Retired (3)	Charges for Property Installed (4)	Credits for Property Retired (5)	Remarks (6)	Added (7) Cost	Retired (8) Cost	Added (9) Cost	Retired (10) Cost	Added (11) Cost	Retired (12) Cost	Added (13) Cost	Retired (14) Cost	
1															1
2															2
3															3
4						Note:- Columns should be printed on reverse side. A continuation sheet should be used the same as this form but omitting columns 2, 3, 4, 5 and 6. To indicate quickly to the eye, the continuation sheet should be printed in a different color. Size of form 11"×22"										4
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6															6
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35															35

Binding Margin

a new line of railroad is shown on the profile or track chart and that for any subsequent rail changes for main and side tracks the attached form be used for each "Authority for Expenditure."

The Committee recommends that Exhibit 28 be used to definitely record the history and location of each rail change for each "Authority for Expenditure."

(k) Record of Ballast Changes—Ballast Chart (Exhibit 29)

In the study of changes in physical property, the Committee has found that the problems of accounting and valuation for ballast are very important and recommends a record and a method of reporting new ballast changes for each "Authority for Expenditure," assuming that in the original construction a construction profile or track chart will show the ballast applied, although the form recommended by the Committee can readily be used.

The accounting methods for ballast changes are particularly complex for the reason that it is difficult to distinguish between expenditures for new or additional ballast and replacements, restoration of embankment and similar features.

The accounting procedure for ballast work should always be definitely illustrated in graphical form.

The Committee, accordingly, recommends the use of Exhibit 29.

(l) Record of Rail in Main Track, and Record of Heat Numbers (Exhibits 30 and 31)

Within the last few years the Committee finds that the practice of making a field inventory of the location of each rail in main track has become necessary. This information should be developed so as to have a record of all the rails in any one heat, which has been brought about by the desire to remove or have under observation all rails when transverse fissures occur in rails of any particular heat.

The Committee has studied the methods used by various carriers and arrived at the conclusion that Exhibits 30 and 31 represent the best method to develop and record information as to location of rails of the same heat number.

(4) FORMS FOR ANALYSIS OF EXPENDITURES AND COMPARISON WITH ACTUAL CHANGES IN PHYSICAL PROPERTY

(a) "Consolidation Sheet" for Analysis of Expenditures (Exhibit 6)

In accounting for the expenditures that are incurred for labor, material and other elements of cost, which originate from payrolls, material bills, vouchers and from several other sources, and in keeping up-to-date the valuation records, compiling the cost of construction work, preparation of Roadway Completion Reports and cost data, the expenditures must be accumulated to each designated unit, and, at the same time, the number of units must be accumulated and reconciled with the expenditures.

Size 11×17 inches

Exhibit 6

North & South Railroad
CONSOLIDATION SHEET A.F.E. 1000

Eastern Division
84'- 5 Pile Open Deck Pile Trestle

Sheet No. 1 of 1

Compiled by John Doe
Date 3-10-24

			Labor			Work Train Service						Material			Miscl. Expense		
Month	Year	Source	Labor Unload Piling	Labor Cut-off Piling	Labor Driving Piles	Unload & Drive Piles Labor	Unload & Drive Piles Material	Unload & Drive Piles Miscl.				Pcs.	Lin.ft. @	Cost	Store Expense	Transportation of Material	Rent of Equipment
December	1923	Divn. Accts	43.10	15.70	156.25	90.23	40.17	2.22				20-35'	700 .50	350.00	1.75		
January	1924	" "		7.20	64.20	10.05	3.90	.27				20-30'	600 .50	300.00	1.50		
Total As Charged in the Accounts			43.10	22.90	220.45	110.28	44.07	2.49				40	1300	650.00	3.25	-	-
Adjustment in the Accounts			-	-	-	-	-	-				2	60	30.00	.15	27.20	21.60
Completion Report			43.10	22.90	220.45	110.28	44.07	2.49				43	1360	680.00	3.40	27.20	21.60

Note- This sheet represents the method of summarizing labor, material, work train, store expense, transportation, rental of equipment or any other element of expense, for the unit piling. There is shown detailed material items as was charged out in the accounts, invoiced quantities in the structure when completed and the adjustment necessary to correct the accounts.

Total as Charged in the Accounts	1,096.54
Adjustment in the accounts	78.95
Completion Report	1,175.49

The purpose of a Consolidation Sheet is to furnish a work sheet so as to post each month all the material items used, together with the corresponding expenditures, and to accumulate these items and then finally to compare the accumulation of units with a final inventory, or units measured from some other sources than the accounts.

In handling the accounting for construction projects it is found that irregularities occur in accounting practice with such frequency that such a comparison is necessary for reason of the erroneous detail involved, and any differences must be credited or debited to the source.

The Committee has found, in actual practice, that numerous work sheets always must be used, and in order to systematize the method the use of Exhibit 6 is recommended.

(b) Cost of Property Retired (Exhibit 7)

In the handling of the records and accounts in connection with Investment accounting that is required by accounting regulations, it is necessary to ascertain or to develop the cost of property retired by three classifications, as follows:

Property Retired and Replaced
Property Retired and Not Replaced
Betterments.

The mandatory regulations require that carriers write out of their Investment Accounts units of property retired at ledger value (estimated if not known).

As this fundamental principle has only been specified in detail in recent years, the records of many carriers do not show ledger value for all property classed as "Property Retired and Replaced" that is retired from transportation service; accordingly the Committee has deemed it necessary to design Exhibit 7 to fit the various conditions encountered in attempting to develop the cost of property retired.

The usual accounting procedure requires that a retirement entry be set up by the various primary accounts, and, in a like manner, the records that are required by Valuation Order No. 3 specify that property which is retired be detailed by accounts.

Another feature that a carrier's own accounting needs requires is that any retirement entry not only should show the accounts to be credited but those accounts that are to be debited; accordingly the need of proper retirement detail is obvious.

It is considered as approved practice that when developing the "ledger value" of property retired the following procedure is correct:

(1) Ascertain the ledger value of property retired, if shown on the carrier's books, and if not, as is frequently the case, there should be ascertained those units shown in the Engineering Report (Interstate Commerce Commission) and estimate the original cost of such units as of the date of construction.

(2) As it is an accounting fundamental that a unit of property is anything ordinarily recorded separately in the carrier's Investment Account, such property which is to be retired that has been recorded on Roadway Completion Report subsequent

to date of carrier's valuation, should be retired at its actual cost unless the property change is accounted for as a "Betterment."

The conclusion developed in connection with item No. 1 above and subsequent property changes to the carrier's date of valuation, as reported under Valuation Order No. 3, should be combined in determining ledger values, when circumstances require it.

Size 8½ x 11 inches — Exhibit 7

North & South Railroad
COST OF PROPERTY RETIRED

Date..... Valuation Section..... A.F.E. No.....

Location and Description.....

Date Retired..... Was Property, Destroyed, Moved Or Abandoned.....
Date Originally Constructed..... Under Authority No.....
How were the quantities and costs given in statements below obtained?.....

Asset No.	Description of Item	Unit	No. of Units	Unit Cost	Amount	Remarks

(3) Through the process of maintenance, property changes occur, the cost of which are not charged to the carrier's Investment Account; accordingly an inventory or survey of existing conditions, preceding retirement, is usually necessary as a check of features No. 1 and No. 2 above, and is further necessary to develop the salvage to be recovered. Any differences that may be determined between property actually existing prior to retirement and as estimated, using the principles laid down in paragraphs No. 1 and No. 2 above, should not be credited to the carrier's Investment Account.

The use of the features and principles described in the foregoing is considered good practice and has the approval of the regulatory bodies in connection with accounting and valuation.

The use of approved and uniform methods is necessary to conform with legal requirements, as the amount charged to a carrier's Operating Expenses in connection with retirements is of vital importance in the application of the Transportation Act, 1920, and this Committee considers it important to set forth approved procedure.

Amounts credited to a carrier's Investment Account and charged to "Profit and Loss" for "Property Retired and Not Replaced" are important in connection with the Internal Revenue Act, as well as for valuation and other purposes.

This same form is applicable for property retired under the classification of "Property Retired and Not Replaced."

For that class of property removed from transportation service, classified as "Betterments," it is necessary to use work sheets, or a form to detail units of material that are replaced with improved units and the form designed will meet that need.

Exhibit 7 as designed contemplates that the report should be divided into appropriate sub-headings in accordance with the classification of property retired, viz.:

(A) Property Retired and Replaced.
(B) Property Retired and Not Replaced.
(C) Property Retired in Connection with Betterments.

Each of the foregoing classifications should be further sub-divided, when necessary, to the following:

(1) Property Retired, Charged to "Road and Equipment" when Installed.
(2) Property Retired, Charged to Operating Expenses, or Other Accounts when Installed.

The statement on this report of "Property Retired, Charged to Operating Expenses when Installed," is necessary to determine the accounting and salvage recovered. The statement under heading of "Property Retired, Charged to 'Road and Equipment' when Installed," should be the quantities included in the Engineering Report, or Land Report, broken down in sufficient detail from inventory notes, D.V. Form No. 107, 108, etc., to which should be added or deducted subsequent detail of property changes as reported by Valuation Order No. 3, Roadway Completion Reports; therefore the other statement, consisting of retirements, originally charged to Operating Expenses, should be all other items not included under this description.

Conclusions

A form is essential to develop the cost of property retired in any system of records and accounts involving property retirements, and Exhibit 7 is recommended for that purpose.

(c) **Cost Data Analysis** (Exhibit 8)

There are a number of methods by which railways can record and accumulate construction cost data, but none suggests itself as flexible as the card index form, by units. Accordingly, the Committee has designed the form shown. The data is to be recorded from roadway completion reports. It can be said, however, that a record of this kind overlaps to a partial extent the record of property change form.

Size 5 x 8 inches Printed both sides Exhibit 8

Account.....
Unit or Item.....
Year

A.F.E.	Location	Description	Quantity	Cost	Unit Cost

(5) MANDATORY FORMS REQUIRED BY FEDERAL REGULATIONS

(a) **A.F.E. ("Authority for Expenditure")** (Exhibit 9 (Present Form 1113 Revised)

Consideration has been given to the use of "Authority for Expenditure" in connection with the subject of "Collecting, Compiling, Recording and Filing Physical Changes in Property," and it has been found that Form 1113, on page 513, of the Manual, does not cover all features that must be considered in asking authority to make a change in the physical property.

The Committee has designed and submits a revised Form 1113, Exhibit 9, which contains provision to secure authority for the following classifications of work:

Additions
Betterments
Property Retired and Replaced
Property Retired and Not Replaced
Property Changes Charged to Operating Expenses, Account the $100.00 Minimum.

(b) **Detailed Estimate Sheet** (Exhibit 10) (Present Form 1114 Revised)

Consideration has been given in Form 1114, appearing on page 516 of the Manual, and it is thought by the Committee that there are more columns shown in detailed estimate form than are generally used; accordingly a revised Form 1114, Exhibit 10, as shown, is recommended.

This form is recommended as good practice.

Exhibit 9
(Present Form 1113-Rev.)

Size 8½ x 11 inches

North & South Railroad
AUTHORITY FOR EXPENDITURE

A.F.E. No.. . . .

Authority for an Expenditure of $ . . . . . is requested for the purpose of . . . . . .to the property of . . . . . that is operated by . . . . . .

Location of Project: Station or M.P. . . . . .Valuation Section . . . . . .

Description of Project:

Reasons and necessity for the extension, improvement or other change:

SUMMARY OF ESTIMATE

1. Estimated gross cost of project . . . . . $
   Amount chargeable to:
2. Reserve for accrued depreciation for property retired. . . $
3. Profit and loss for property retired . . . . . .
4. Operating expenses for property retired. . . . . .
5. Value of salvage recovered . . . . . .
6. Cost of property retired. . . . . $
7. Incidental costs chargeable to profit and loss . . . . . .
8. Incidental costs chargeable to operating expenses. . . . . .
9. To other accounts . . . . . .
10. Net charge to property investment account. . . . . $
11. Charge to Operating Expenses-Order of I.C.C. dated January 14, 1921. . . . . $

Total cost to be borne by . . . . . or participated in by . . . . . $
. . . . . $

Recommended _____ _____
(Name) (Title)
_____ _____
(Name) (Title)
Approved _____ _____
(Name) (Title)
_____ _____
(Name) (Title)
Approved and Authorized _____ _____
(Name) (Title)

Date of Final Approval and Authorization _____, 19_____

(c) **Record of Property Changes** (Exhibits 21, 22 and 23)

The "Record of Property Changes," generally spoken of as Exhibit "E" of Valuation Order No. 3, Second Revised Issue, is a record that was originally designed for the dual purpose of recording and consolidating units of a like kind that are added and deducted periodically from the property of the carrier, and, also, to record and accumulate expenditures by debits and credits

periodically. The record is primarily to perpetuate the Federal Valuation by units and by money.

As a record of expenditures it differs from the usual railway accounting procedure in recording the Investment charges currently, in that Exhibit "E" requires a record of final or total expenditures only when the project is in transportation service, whereas the accounting method is to report chronologically the debits and credits as they originate from any source.

Exhibit 10
(Present Form 1114 - Rev)

Size 8½x11inches

North & South Railroad
DETAILED ESTIMATE

Plan No.....
Office of.....
Date.....19.....
A.F.E. No.....
Sheet No.....of.....Sheets
Reference.....
Location and Description of Project:.....

Acc't No.	Items And Description	Unit	Quantity	Rate Per Unit	Amount

Estimated by.....Checked by.....Approved.....

There is a growing thought in connection with this record, which is tending towards the abolition of the method of showing units and it may be that in the future the only record that will be required will be one to record only gross charges and gross credits, by valuation sections, by primary Investment accounts.

The Committee, in its investigation of the entire subject, is of the opinion that this record serves no useful purpose to carriers and that as

years go by the immense volume of the record will be such as to preclude any possible use. It has been found that those carriers who have attempted to use the record, after a lapse of some years from the date they were valued, found it necessary to seek recourse in the basic record, the Roadway Completion Report, in order to bring the valuation down to date on any basis.

So long as carriers are required to maintain a "Record of Property Changes," the Committee recommends two methods as follows:

Roadway Changes

(1) Exhibit 21 has been designed for the use of the larger carriers and it permits of recording the units added and the units retired with the attendant costs of such units. It is similar to the mandatory form in Valuation Order No. 3, Second Revised Issue, except that several additional columns have been provided so as to allocate the cost to units added and retired.

(2) For the smaller carriers, Exhibits 22 and 23 have been designed for recording property changes. Exhibit 22 requires a separate sheet for each unit; accordingly there will be a number of sheets for each primary account.

The record is to be maintained separately by valuation sections and is of some advantage over Exhibit 21 as it permits of accumulating the expenditures, year after year, for any group of units, particularly by individual structures.

Each year the gross charges and gross credits recorded on Exhibit 22 should be summarized on Exhibit 23 for the purpose of preparing the annual returns to the Investment Account as required by Valuation Order No. 3, Second Revised Issue, on B.V. Form No. 589.

Equipment Changes

The subject of recording equipment changes has been covered under Subject No. 3, "Forms for Recording Changes in Physical Property," (h) "Equipment Index—Record of Property Changes," and the recommendations are that the method outlined should be followed, in lieu of using the same "Record of Property Changes" as for roadway work.

(6) LIST OF UNITS OF RAILWAY PROPERTY

The Committee has given consideration to units that are ordinarily used in reporting and recording railway construction work and the units used by the Bureau of Valuation when inventorying the property of the railways in connection with Federal Valuation. Consideration has also been given to the published List of Units as designated by the Bureau of Valuation, collaborating with the Presidents' Conference Committee and published by the latter organization January 10, 1921.

The List of Units as published by the Presidents' Conference Committee has been widely distributed and is generally used by the railroads in complying with the requirements of Valuation Order No. 3. This List of Units is similar to the Units as used by the various districts of the Bureau of Valuation in their inventory work. While each district had

slightly different methods, yet in principle the Units, as used, were similar throughout the country.

The Committee has concluded that the List of Units published by the Presidents' Conference Committee, January 10, 1921, has been used successfully and it is practical to allocate costs to these units and to record the units in the manner made mandatory by Valuation Order No. 3 and in any construction records. There are a number of slight changes that should be made that are considered good engineering practice, which are found necessary due to conditions that have changed subsequent to January 10, 1921. The Units as published and generally used, by the Presidents' Conference Committee, have been tested principally in connection with improvements to existing properties of the railroads rather than on new lines and extensions, owing to very little work of the latter character being done in the United States since the date of publication.

The Committee has arrived at the conclusion that changes as follows should be made, and that the additions be made, as shown below:

Account No. 2—Land for Transportation Purposes

There should be added to the instructions under this primary account, requirements that the number of each parcel, map number, zone number, dimensions, and general characteristics of the land be indicated on the completion report. The requirements of Supplement No. 1 to Valuation Order No. 3 make it necessary that sufficient data as to improvements, character, etc., be reported in that system of reports. As there are occasional transfers in the carrier's accounts between "Land for Transportation Purposes," and "Miscellaneous Physical Property," it is obvious that more complete details are required in connection with all land transactions.

Account No. 3—Grading

The Committee recommends the addition of the unit "Mattress (Kind) ..... lin. ft." for work in connection with protection of roadway, prevention of streams eroding their banks, etc.

Account No. 6—Bridges, Trestles and Culverts

The published List of Units under this account does not provide an item for frame bents under the sub-heading of pile and frame trestles. Owing to the large number of frame trestles, some prominence should be given to a unit of this character and Committee recommends the addition of item "Frame bents ..... M. Ft. B. M."

The description for the unit "Pipe, Cast Iron," should be amplified by the addition of the words (Kind and Specifications). There is generally pipe with specifications of either light, standard, medium, or heavy used in railway construction. Accordingly, it is not proper to record units of this kind under one group.

Account No. 9—Rails

It is considered advisable by the Committee that the unit of "Taper rails" be shown under this account in order to avoid any conflict with any units shown under Account No. 10—"Other Track Material."

Account No. 10—Other Track Material

The Committee considers that the units as shown under this account are substantially correct, but feel that where the unit hundred weight (cwt.) appears it should be changed to pounds (lb.). It is also recommended that all joints except plain angle bars be listed by either joints or pairs with a view to obtaining simplicity.

It is recommended that the description under the unit "Switches, Slips, Complete," be amplified by instructions to show the distance from heel of end frogs in order to compute the rail deduction. There are so many variations between various slip switches that the description should be complete in regard to this feature.

The unit "Bumping Posts" should be more complete, as when any posts of this kind are not special or patented, such as concrete, earth, or lumber, there should be recorded full details with the appropriate units of measurements reported, such as cubic yards of concrete, or common excavation, or M. Ft. B. M. of lumber.

It is recommended that there be added to List of Units under this account the following:

Car Stops	each
Rail Clips	each
Drawbridge Fastenings	set

Account No. 12—Track Laying and Surfacing

In view of the preponderance of work being done in connection with the improvements to the existing line of railroads, it is recommended that the unit "Lin. Ft." be used in lieu of "Miles" as shown.

It is recommended that new units be added as follows:

Derails	each
Tie Plates	each
Anti-Creepers	each
Railroad Crossings	each
Bumping Posts	each
Bridge and Curve Guard Rails	lin. ft.

Account No. 13—Right-of-Way Fences

It is recommended that the "Lin. Ft." unit be used instead of "Miles" for right-of-way fences in view of the preponderance of work by railroads at this time is in connection with improvements to existing properties.

Those minor units shown under this account such as posts, lumber, wire, etc., should be eliminated and the description for the unit "Fence," which is recommended as above, should be reported as a "Lin. Ft." unit and should be elaborated upon in the description. It is illogical to build up costs to such minor units as posts, lumber, wire, etc., and fencing should be described as to type, number of wires, spacing of posts, etc., and the cost built up to a "Lin. Ft." unit.

Account No. 15—Crossings and Signs

The Unit "Paving (kind)" should always be reported by indicating the depth, cushion, and foundation in addition to the kind.

Account No. 16—Station and Office Buildings

The Committee suggests that the descriptive matter under the unit "Building, Complete," for important buildings should be treated more in detail. A separation should be made in connection with the important buildings to show units for lumber, floors, brickwork, hardware, structural steel, roofing, painting, etc.

In major building work it is logical to separate the electrical work as between fixtures, wiring, conduit, etc., and show the number of outlets.

It is also proper in connection with large building work to break down the cost of heating and the quantities in connection therewith as between the heating plant proper, radiation, piping, etc.

It is recommended that the units in connection with stock pen work be changed so that work of this character can be reported on a "Lin. Ft." basis for that type of stock pen where fencing is the principal work. Those stock pens having sheds, concrete floors, etc., should be reported in accordance with the appropriate units for that class of work shown under other accounts.

Account No. 18—Water Stations

It is recommended that sufficient descriptive matter be shown under this account in connection with pipe lines to indicate that a separation be made between the tank proper and piping beneath the surface of the ground, so as to obtain a separation at the frost box, in view of the fact that pipe lines within a frost box are part of the tank system and not part of the distribution system.

General

The Committee has no definite recommendations to make in connection with other accounts than shown above, and it is the conclusion that separation as made other than as commented is logical and good practice in reporting engineering work and costs.

LIST OF UNITS

This list of units compiled jointly by the Bureau of Valuation, Interstate Commerce Commission, and the Presidents' Conference Committee. Published by the Presidents' Conference Committee January 10th, 1921.

Account No. 1.—Engineering

Item	Unit
No units are required for this account. Costs shall be shown in the appropriate columns.	

Account No. 2.—Land for Transportation Purposes

Land for transportation purposes and R. of W. On the completion report, or as a supplement thereto, there should be sufficient description to cover the general character of the land reported as a whole. Such description may be indicated as required by D. V. Forms Nos. 107 and 108. If the carrier so elects, these forms may be used as a supplement to and form a part of the completion report.	Acre or Sq. Ft.

Account No. 3.—Grading

Clearing ..... Acre
Grubbing ..... Acre
Excavation:
- Earth or common ..... Cu. Yd.
- Loose rock ..... Cu. Yd.
- Solid rock ..... Cu. Yd.
- Other material (kind) (wet or dry) ..... Cu. Yd.
- Unclassified ..... Cu. Yd.

Embankment (kind) ..... Cu. Yd.
Overhaul, team ..... Beyond ..... Ft. ..... Cu. Yd. per 100 Ft.
Overhaul, train ..... Beyond ..... Ft. ..... Cu. Yd. per 1,000 Ft.
Protection of roadway:
- Sodding ..... Sq. Ft. or Sq. Yd.
- Masonry (kind) ..... Cu. Yd.
- Concrete (kind) ..... Cu. Yd.
- Rip-rap (kind) ..... Cu. Yd.
- Pipe, cast iron ..... Net Ton (2,000 lb.)
- Pipe, other (kind and size) ..... Lin. Ft.
- Piling (kind) (net in place) ..... Lin. Ft.

Sheet piling:
- Timber ..... M. Ft. B. M.
- Steel ..... Lb.

Paving (kind) (for appropriate units see Account No. 15).
Cribbing (kind) ..... M. Ft. B. M.
Logs ..... Lin. Ft.
Brush mattress (kind) ..... Sq. Yd.
Hardware ..... Lb.
(For additional units see Account No. 6).

Account No. 4.—Underground Power Tubes

Excavation (kind) ..... Cu. Yd.
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Cu. Yd.
Iron or steel ..... Lb.
Drain pipes, cast iron ..... Net Ton (2,000 lb.)
Drain pipes, other (kind and size) ..... Lin. Ft.
Sheaves (kind and size) ..... Each
Yokes (kind and weight) ..... Each
Manhole castings ..... Lb.
Slot rails (kind and weight per yard) ..... Lin. Ft.
Underground conduit, in place (kind and size) ..... Duct. Ft.

Account No. 5.—Tunnels and Subways

Excavation:
- Earth or common ..... Cu. Yd.
- Loose rock ..... Cu. Yd.
- Solid rock ..... Cu. Yd.
- Other material (kind) ..... Cu. Yd.
- Unclassified ..... Cu. Yd.

Overbreak ..... Cu. Yd.
(Classify materials as shown under excavation.)
Shafts:
(Classify materials as shown under excavation.)
Overhaul, team ..... Beyond ..... Ft. ..... Cu. Yd. per 100 Ft.
Overhaul, train ..... Beyond ..... Ft. ..... Cu. Yd. per 1,000 Ft.
Lining, shafts and portals:
- Timber (kind) ..... M. Ft. B. M.
- Masonry (kind) ..... Cu. Yd
- Concrete (kind) ..... Cu. Yd.

Steel and iron ..... Lb.
Waterproofing (kind, number of plys, etc.) ..... Sq. Yd.
Pipe, cast iron ..... Net Ton (2,000 lb.)
Pipe, other (kind and size) ..... Lin. Ft.
Packing or backfilling:
Common ..... Cu. Yd.
Rock ..... Cu. Yd.
Timber (kind) ..... M. Ft. B. M.
Cord wood ..... Cord
Manhole castings ..... Lb.
Ventilating apparatus, complete installation (description) ..... Each
Lighting system, complete installation (description) ..... Each

Account No. 6.—Bridges, Trestles and Culverts

Steel bridges:
Substructure:
Excavation (wet or dry), classified if necessary ..... Cu. Yd.
Foundation, timber (kind) ..... M. Ft. B. M.
Foundation, metal (kind) ..... Lb.
Piles (kind) (net in place) ..... Lin. Ft.
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Cu. Yd.
Caissons—
Pneumatic or other important caissons, report each separately in the units given above.
Superstructure—
Metal (kind) ..... Lb.
Guard, timber ..... M. Ft. B. M.
Drawbridge machinery ..... Lb.
Power apparatus, complete ..... Each
Pile and frame trestles:
Excavations (wet or dry), classified is necessary ..... Cu. Yd.
Piling (kind, net in place) ..... Lin. Ft.
Stringers (kind) ..... M. Ft. B. M.
Other lumber (kind) ..... M. Ft. B. M.
Metal (kind) ..... Lb.
Hardware ..... Lb.
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Cu. Yd.
Water barrels (kind) ..... Each
Masonry and concrete bridges and culverts:
Excavation (wet or dry), classified if necessary ..... Cu. Yd.
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Sq. Yd. or Cu. Yd.
Paving (kind) ..... Cu. Yd.
Foundation—
Timber (kind) ..... M. Ft. B. M.
Metal ..... Lb.
Piling (kind) (not in place) ..... Lin. Ft.
Culverts, pipe or timber:
Excavation (wet or dry), classified if necessary ..... Cu. Yd.
Pipe, cast iron ..... Net Ton (2,000 lb.)
Pipe, other (kind and size) ..... Lin. Ft.
Timber (kind) ..... M. Ft. B. M.
Logs ..... Lin. Ft.
Hardware ..... Lb.
Waterproofing (kind, number of plys, etc.) ..... Sq. Yd.
Rip-rap (kind) ..... Cu. Yd.
Bridge signs (kind) ..... Each
(For other appropriate units see Accounts Nos. 3 and 15.)

Account No. 7.—Elevated Structures

(For appropriate units see Account No. 6.)

Account No. 8.—Ties

Main tracks:
- Cross-ties (kind and size) ..... Each
- Cross-ties, metal (weight each) ..... Each
- Bridge ties (kind) ..... M. Ft. B. M.
- Switch ties (kind) ..... M. Ft. B. M.
- Switch ties (metal) ..... Lb.

Yard and other tracks:
- Report separately in same units as for main tracks.

Account No. 9.—Rails

Main tracks:
- New rail—
  - Bessemer, weight per yard ..... Gr. Ton
  - Open-hearth, weight per yard ..... Gr. Ton
  - Other kinds, separately, weight per yard ..... Gr. Ton
- Re-rolled rail, actual weight per yard ..... Gr. Ton
- Relay rail—
  - Bessemer, original weight per yard ..... Gr. Ton
  - Open-hearth, original weight per yard ..... Gr. Ton
  - Other kinds, separately, original weight per yard ..... Gr. Ton

Yard and other tracks:
- Report separately in same units as for main tracks.

Account No. 10.—Other Track Material

Main tracks:
- Angle and splice bars (common) ..... Cwt.
- Joints, patent, insulated or special ..... Joint
- Joint, compromise ..... Cwt.
- Bolts ..... Cwt.
- Nutlocks (kind and size) ..... M.
- Spikes (kind) ..... Cwt.
- Tie plates (kind) ..... Cwt.
- Base plates (under joint) ..... Lb.
- Rail braces (kind of material, weight per unit) ..... Each
- Frogs, rigid (kind, length, weight of rail) ..... Each
- Frogs, spring (kind, length, weight of rail) ..... Each
- Frogs, crossing (kind, number of rails, weight of rails, angle length, with or without base plates, total weight) ..... Each
- Switches, complete (kind, weight of rail, reinforcement, etc.) .... Each
- Switches, slip, complete ..... Each
  - Including guard rails, center and end frogs and accompanying stock rails, unless otherwise noted. (State, number, single or double; weight of rail; whether frogs are manganese or common; rigid center or movable point. Thus—No. 10, double slip switch, 90 lb., rigid, manganese insert frogs.)
- Switch stands (kind), high medium, low, ground, etc ..... Each
- Switch lamps (kind) ..... Each
- Switch padlocks ..... Each
- Guard rails, common ..... Lb.
  - Including filler blocks and bolts.
- Guard rail clamps (kind and size) ..... Each
- Guard rails, special (kind, size and length) ..... Each
  - Including attachments.
- Other guard rail (bridge, curve, etc.) ..... Gr. Ton
- Derails, complete (kind and size) ..... Each

Bumping posts (kind) ..... Each
Rail rests (kind) ..... Each
Anti-creepers (kind and size) ..... Each
Gauge rods or bridles not in switches ..... Each
Yard and other tracks:
Report separately in same units as for main tracks.

Account No. 11.—Ballast

Main tracks:
Ballast (kind) ..... Cu. Yd.
Yard and other tracks:
Report separately in same units as for main tracks.

Account No. 12.—Track Laying and Surfacing

Main tracks:
Track laying, including running surface ..... Mile
Track laying, including full earth surface ..... Mile
Track laying, on open deck bridges ..... Mile
Placing ballast (kind) ..... Cu. Yd.
Placing turnouts, crossing frogs, tie plates, rail braces, anti-creepers, etc. ..... Each
Framing and placing bridge ties ..... M. Ft. B. M.
Maintenance during construction ..... Mile
Yard and other tracks:
Report separately in same units as for main tracks.

NOTE.—Track laying for various weights of rail should be separated into the following groups:
60-lb. rail and under,
61-lb. to 90-lb. rail,
91-lb. rail and above.

Account No. 13.—Right-of-Way Fences

Fence (if standard) ..... Mile
(For standard fence give kind, size and spacing of posts and description of panel.)
Posts (kind and size) ..... Each
Lumber (kind) ..... M. Ft. B. M.
Wire (kind) ..... Lb.
Cattle guards (kind, number of sections) ..... Each
Gates (kind and size) ..... Each
Aprons or "A" frames ..... Each
Hardware ..... Lb.
Special fences, ornamental iron, hedges, etc. (kind) ..... Lin. Ft.
Masonry fences (kind) ..... Cu. Yd.
Concrete fences (kind) ..... Cu. Yd.

Account No. 14.—Snow and Sand Fences and Snow Sheds

Snow fence (if standard) ..... Mile
(For standard fence give kind, size and spacing of posts and description of panel.)
Posts (kind and size) ..... Each
Lumber (kind) ..... M. Ft. B. M.
Ties (kind) ..... Each
Hardware ..... Lb.
Metal ..... Lb.
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Cu. Yd.
Excavation (kind) ..... Cu. Yd.
Embankment or filling ..... Cu. Yd.
(For additional units see Account No. 3.)

Account No. 15.—Crossings and Signs

Crossing plank (kind) ..... M. Ft. B. M.
Paving (kind) ..... Sq. Yd.
Sidewalks (kind) ..... Sq. Ft.
Curbing (kind and size) ..... Lin. Ft.
Gutter (kind and size) ..... Lin. Ft.
Crossing bells (kind), complete outfit ..... Each
Warning signals (kind), complete outfit ..... Each
Crossing gate outfit, complete, excluding building ..... Each
Signs (kind) ..... Each
Annunciator, complete outfit ..... Each
Drainage system. (For appropriate units see Account No. 6.)
For additional units see Accounts Nos. 3, 6, etc.

Account No. 16.—Station and Office Buildings

Important buildings shall be reported separately with description and location; smokestacks to be included with building.
Building complete (description and size, volume or area) ..... Each
Including foundation, heating, lighting, and plumbing, except furniture.
Important buildings should show separately (on the Completion) Report), foundation, superstructure, heating, lighting and plumbing.
Furniture (each building) ..... Lot
Important or unusual pieces of furniture ..... Each
Platform:
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Cu. Yd.
Timber (kind) ..... M. Ft. B. M.
Filling (kind) ..... Cu. Yd.
Metal ..... Lb.
Curbing (kind and size) ..... Lin. Ft.
Paving (kind) ..... Sq. Ft.
Platform (if standard) ..... Sq. Ft.
(Complete description.)
Stock pens:
Fence (if standard).
(For appropriate units see Account No. 13.)
Lumber (kind) ..... M. Ft. B. M.
Posts (kind and size) ..... Each
Hardware ..... Yd.
Paving (kind) ..... Sq. Yd.
Scales (kind and capacity) ..... Each
Drainage systems. (For appropriate units see Account No. 6.)
Water supply systems. (For appropriate units see Account No. 18.)
Coal bins (detached) ..... Each
Coal and ore transferring machinery (not on coal and ore wharves) . Plant
Freight derricks (kind and capacity) ..... Each
Freight handling machinery (kind) ..... Plant
Mail cranes (kind) ..... Each
Scales, track:
Excavation. (For appropriate units see Account No. 3.)
Drainage. (For appropriate units see Account No. 6.)
Concrete (kind). (For appropriate units see Account No. 6.)
Masonry (kind). (For appropriate units see Account No. 6.)
Timber (kind). (For appropriate units see Account No. 6.)
Scale, maker and capacity, including mechanism, structural steel and castings ..... Each

Scales, other (description and capacity) .....Each
Trucks (kind) .....Each
Landscape gardening .....Sq. Yd.
Sidewalks, paving, curbing, gutters, etc. (For appropriate units see Account No. 15.)

Account No. 17.—Roadway Buildings

Buildings and appurtennaces. (For appropriate units see Account No. 16.)
Machinery. (For appropriate units see Account No. 44.)

Account No. 18.—Water Stations

Building, excluding machinery. (For appropriate units see Account No. 16.)
Water tanks:
- Foundations. (For appropriate units see Account No. 6.)
- Tanks (kind, size and capacity).....Each
- Supports, steel .....Lb.
- Supports, timber (kind).....M. Ft. B. M.
- Supports, masonry (kind).....Cu. Yd.
- Supports, concrete (kind).....Cu. Yd.
- Steel tank and tower combined.....Each
  - State dimensions, capacity and height from top of foundation to bottom of tank.
- Frost protection (kind and size).....Lin. Ft.
- Tank spout and fixtures (kind and size).....Each

Water crane (kind and size), including pit, lining, etc.....Each
Pipe lines, including fittings:
- Pipe, cast iron.....(2,000 lb.) Net Ton
- Pipe, other (kind and size).....Lin. Ft.

Reservoirs and settling basins. (For appropriate units see Account No. 3.)
Track tanks:
- Troughs .....Lin. Ft.
- Piping, subways, masonry, protection, etc. (See appropriate units above and in Accounts Nos. 3 and 5.)

Cisterns and dug wells:
- Excavation .....Cu. Yd.
- Lining—
  - Masonry and brick work.....Cu. Yd.
  - Concrete (kind) .....Cu. Yd.
  - Timber (kind) .....M. Ft. B. M.
  - Pipe (kind and size).....Lin. Ft.

Wells, driven, bored or drilled (size).....Lin. Ft.
Including casing.
Pumping machinery:
- Boilers (kind, maker and horse power).....Each
  - Including foundation and setting.
- Pumps (kind, maker, size and capacity).....Each
  - Including pump jack
- Engines (kind, maker, size and horse power).....Each
- Motors (make, type, R.P.M. and capacity).....Each
  - Including switchboard, rheostat and connections.
  - Note.—Include foundation with unit unless included with part of building.
- Windmills (kind, diameter of wheel and height of tower).....Each

Water treating plant (kind and capacity):
- Units shown above where applicable, otherwise plant complete..Each

Account No. 19.—Fuel Stations

Fuel stations, plant complete (description, kind, capacity, etc.) ..... Each
Excluding approach or tail trestle and embankment.
Other buildings ..... Each
Grading, trestles, drainage, sidewalks, paving, etc. (For appropriate units see Accounts Nos. 3, 6, 15, 16, etc.)

Account No. 20.—Shops and Enginehouses

Important buildings shall be reported separately with description and location.
Building, complete (description and size, volume or area) .... Each
Including foundation, heating, lighting and plumbing, except furniture.
Important buildings should show separately (on the Completion Report) foundation, superstructure, heating, lighting and plumbing.
Turntables and transfer tables:
Excavation. (For appropriate units see Account No. 3.)
Drainage. (For appropriate units see Account No. 6.)
Masonry (kind). (For appropriate units see Account No. 6.)
Concrete (kind). (For appropriate units see Account No. 6.)
Timber (kind). (For appropriate units see Account No. 6.)
Pit rail (kind) ..... Lb.
Track fastenings. (For appropriate units see Account No. 10.)
Table, metal (length) ..... Lb.
Table, wood (length) ..... Each
Table, tractor (kind) ..... Each
Cinder pits:
Excavation. (For appropriate units see Accounts Nos. 3 and 6.)
Masonry (kind.) (For appropriate units see Accounts Nos. 3 and 6.)
Concrete (kind). (For appropriate units see Accounts Nos. 3 and 6.)
Drainage. (For appropriate units see Accounts Nos. 3 and 6.)
Etc. (For appropriate units see Accounts No. 3 and 6.)
Ash handling plants, exclusive of pit (description and capacity) ..... Each
Electric-power distribution systems within building (kind) ..... Lin. Ft.
Stacks (detached) (kind and dimensions) ..... Each
Central heating plants:
Boilers (kind, maker and horse power) ..... Each
Including foundation and setting.
Material and supply truck tracks and wheel tracks. (For appropriate units see Accounts Nos. 8, 9 and 10.)
Motor crane tracks. (For appropriate units see Accounts Nos. 8, 9 and 10.)
Pipe lines (kind and size) ..... Lin. Ft.
In place, including fittings.
Platform, shop and yard. (For appropriate units see Account No. 16.)
Tanks, oil and gas (material and capacity) ..... Each
Sandhouse apparatus, complete (description and capacity) ..... Each
Grading, drainage, sidewalks, paving, etc. (For appropriate units see Accounts Nos. 3, 6, etc.)

Account No. 21.—Grain Elevators

Grain elevators, complete (description, kind and capacity) ..... Each
Including conveyors, machinery and fixtures.

Account No. 22.—Storage Warehouses

Storage warehouses:
(For appropriate units see Account No. 16.)

Account No. 23.—Wharves and Docks

Grading. (For appropriate units see Account No. 3.)
Dredging (kind) (scow measurement unless otherwise noted).....Cu. Yd.
Bridges, ferry and transfer (kind, length and width).....Each
Including machinery.
Pontoons (kind and dimensions).....Each
Dock and wharf construction:
Bulkheads, ferry racks, fenders, pile clusters, caissons, wharves, piers, crib work, etc. (For appropriate units see Account No. 6.)
Jetties and breakwaters:
Masonry (kind) .....Cu. Yd.
Concrete (kind) .....Cu. Yd.
Rip-rap (kind) .....Cu. Yd.
Earth or other filling or embankment (kind).....Cu. Yd.
Timber (kind) .....M. Ft. B. M.
Piles (kind) (net in place).....Lin. Ft.
Hardware .....Lb.
Grading, drainage, sidewalks, paving, etc. (For appropriate units see Accounts Nos. 3, 6, etc.)

Account No. 24.—Coal and Ore Wharves

Grading. (For appropriate units see Account No. 3.)
Dredging (kind) (scow measurement unless otherwise noted)....Cu. Yd.
Dock and wharf construction:
Bulkheads, ferry racks, fenders, pile clusters, caissons, wharves, piers, crib work, etc. (For appropriate units see Account No. 6.)
Jetties and breakwaters:
Masonry (kind) .....Cu. Yd.
Concrete (kind) .....Cu. Yd.
Rip-rap (kind) .....Cu. Yd.
Earth or other filling or embankment (kind).....Cu. Yd.
Timber (kind) .....M. Ft. B. M.
Piles (kind) (net in place).....Lin. Ft.
Hardware .....Lb.
Buildings. (For appropriate units see Account No. 16.)
Machinery, small installations .....Plant
Machinery, large installations, subdivide if practicable into separate groups .....Group or Plant
Grading, drainage, sidewalks, paving, etc. (For appropriate units see Accounts Nos. 3, 6, etc.)

Account No. 25.—Gas Producing Plants

Gas producing plant, complete (description and capacity).....Each
Including all apparatus.
Grading, buildings, pipe lines, etc. (For appropriate units see Accounts Nos. 3, 6, 16, etc.)

Account No. 26.—Telegraph and Telephone Lines

Telegraph and telephone material should be reported separately.
Telegraph office apparatus (description).....Set
Including wiring and inside cable.
Telephone office apparatus (description).....Set
Including wiring and inside cable.
Excluding private branch exchange.
Private branch telephone exchange (plan and spec. ref.).....Each
Including switchboard wiring and inside cable.
Excluding branch lines and instruments.

Buildings. (For appropriate units see Account No. 16.)
Telephone booths (kind and size) ..... Each
Portable telephone sets (kind) ..... Each
Roadway telephone box (description) ..... Each
Poles, in place (kind, length and class) ..... Each
Guys (kind, complete) ..... Each
Anchorage (kind and size, complete) ..... Each
Cross arms, in place (kind and size) ..... Each
Including braces and fastenings.
Cross arm pins (kind) 100
Brackets (kind) ..... Each
Insulators (kind) 100
Guard wires (kind) ..... Set
Cable suspension (kind and size) ..... Lin. Ft.
Including fastenings and cable hangers.
Other hardware ..... Lb.
Cable boxes ..... Each
Including wiring and appurtenances.
Aerial cable (kind) ..... Lin. Ft.
State number of pairs, number of single conductors and size.
Underground cable (kind) ..... Lin. Ft.
State number of pairs, number of single conductors and size.
Submarine cable (kind) ..... Lin. Ft.
State number of pairs, number of single conductors and size.
Aerial wire (kind and size) ..... Mile
Underground conduit, in place (kind and size) ..... Duct. Ft.
Pavement (kind) ..... Sq. Ft.
Manholes, complete with equipment ..... Each

Account No. 27.—Signals and Interlockers

Interlocking plant (kind, size, plan and spec. ref.) ..... Each
Tower buildings (kind and size). (For appropriate units see Account No. 16.)
Other buildings (kind and size) ..... Each
Power plant, complete ..... Each
Excluding building, line wires, poles, etc.
Signal bridges. (For appropriate units see Account No. 6.)
Outlying switch protection (kind, plan and spec. ref.) ..... Each
Exclusive of that covered by automatic signals.
Station and train order signals, complete (kind, plan and spec. ref.) .. Each
Including all connections, etc.
Automatic signals, complete (kind and spec. ref.) ..... Each
Exclusive of line wire, poles, etc.
Staff blocks, complete (kind, plan and spec. ref.) ..... Each
Including all accessories, exclusive of line wire, poles, etc.
Gates at crossings of other railways (kind and size) ..... Each
Pole line material. Including line wire, poles, crossarms, etc. (For appropriate units see Account No. 26.)

Account No. 28.—Power Dams, Canals and Pipe Lines

Gates, complete ..... Each
Excluding operating machinery.
Machinery for operating gates, etc., complete. (For appropriate units see Accounts Nos. 3, 6 and 18.)

Account No. 29.—Power Plant Buildings

For appropriate units see Account No. 20.

Account No. 30.—Power Substation Buildings

For appropriate units see Account No. 20.

Account No. 31.—Power Transmission Systems

Wire, in place (kind and size) ..... Mile
Including tie wires.
Cable (kind, maker, sheath and size) ..... Lin. Ft.
State number of pairs, number of single conductors and size, voltage, insulation test.
Switchboards (kind, size, plan and spec. ref.) ..... Each
Transformers (kind, size and spec. ref.) ..... Each
Including wiring, connections, etc.
Oil switches (kind, plan and spec. ref.) ..... Each
Other switches (kind and size) ..... Each
Lightning protection (kind, size and spec. ref.) ..... Each
Including wiring, connections, etc.
Conduits. (For appropriate units see Account No. 26.)

Account No. 32.—Power Distribution Systems

Wire, cable, switch boards, conduits, transformers, oil switches and lightning protection.
(For appropriate units see Account No. 31.)
Trolley wire, in place (kind and size) ..... Lin. Ft.
Third rail, complete, in place (kind and size) ..... Lin. Ft.
Including supports, braces, protection, bonding, etc.
Rail bonding (kind and size) ..... Joint
Pipe lines, in place (kind and size) ..... Lin. Ft.
Including fittings, appurtenances and insulation.
Tunnels and subways. (For appropriate units see Account No. 5.)

Account No. 33.—Power Line Poles and Fixtures

Poles, crossarms and crossarm pins, brackets, guys, insulators, other hardware. (For appropriate units see Account No. 26.)
Pole top extension (kind and specification reference) ..... Each
Transmission on towers and bridges. (For appropriate units see Account No. 6.)

Account No. 34.—Underground Conduits

Conduits, manholes and fitting. (For appropriate units see Account No. 26.)
Sewer connections, in place (kind and size) ..... Lin. Ft.

Account No. 35.—Miscellaneous Structures

For appropriate units see other accounts.

Account No. 36.—Paving

Paving (kind) ..... Sq. Yd.
Curbing (kind and size) ..... Lin. Ft.

Account No. 37.—Roadway Machines

Roadway machines, complete (kind, maker, size or cap.) ..... Each
Including accessories.

Account No. 38.—Roadway Small Tools

Roadway small tools (kind and description) ..... Set
Important or unusual tools ..... Each

Account No. 39.—Assessments for Public Improvements

No units are required for this account. Costs shall be shown in appropriate column. Description should identify and generally indicate the nature of the project.

Account No. 40.—Revenues and Operating Expenses During Construction

No units are required for this account. Amounts in money should be shown in appropriate columns. Revenues and operating expenses should be shown separately, and subdivided by periods when necessary with appropriate descriptions.

Account No. 41.—Cost of Road Purchased

This is a temporary or suspense account. No units are required.

Account No. 42.—Reconstruction of Road Purchased

No units are required in this account.

Account No. 43.—Other Expenditures—Road

No units are required in this account.

Account No. 44.—Shop Machinery

Machines, complete with drive (kind, maker, description and size or capacity) ..... Each
Excluding foundation.
Foundation:
Excavation ..... Cu. Yd.
Masonry (kind) ..... Cu. Yd.
Concrete (kind) ..... Cu. Yd.
Timber (kind) ..... M. Ft. B. M.
Piles (kind) ..... Lin. Ft.
Metal ..... Lb.
Shafting and fittings, complete shop installation, each shop ..... Lot
Including hangers, pulleys, couplings and special supports.
Belting, complete shop installation, each shop ..... Lot
Portable tools:
Important tools (kind and size) ..... Each
Minor tools (each shop) ..... Lot
Engines, boilers, generators and the like. (For appropriate units see Account No. 45.)
Piping, wiring, etc. (For appropriate units see Accounts Nos. 20 and 32.)

Account No. 45.—Power Plant Machinery

Boilers, complete with apparatus (kind, maker and horse power) .... Each
Including setting, breeching or flue, mechanical stokers, induced or forced draft installations, steam heaters, feed water pumps, feed water heaters, etc.
Engines, complete (maker, cylinder size, horse power, R.P.M.) ..... Each
Air compressors, kind, complete (maker, cylinder size, R.P.M. capacity) ..... Each
Engine generator sets, kind, complete (maker, description, R.P.M. capacity) ..... Each
Turbo generator sets, kind (maker, description, R.P.M. capacity) .... Each
Coal or ash handling apparatus, plant complete (description) ..... Each
Condensers (maker, kind, size and capacity) ..... Each
Including pumps and special fittings.
Pipe lines. (For appropriate units see Account No. 32.)
Belting and shafting. (For appropriate units see Account No. 44.)
Batteries, complete (maker, kind and capacity in ampere hours) ..... Cell
Including appurtenances.
Motor generator sets (maker, kind and capacity) ..... Each
Frequency changer sets (kind, maker, capacity) ..... Each

Motors and generators (kind, maker, capacity).....Each
Rotary converters, complete (kind, maker, capacity).....Each
Transformers, power and instrument (kind, maker, capacity).....Each
Switch boards, oil switches and other switches, interior cables, lightning protection. (For appropriate units see Account No. 31.)
Bus bars, complete (weight of bus bar).....Lb.
Including all accessories.
Voltage regulators (kind, maker, size).....Each
Water wheels or turbines (kind, maker, size).....Each
Machine foundations. (For appropriate units see Account No. 44.)

Account No. 46.—Power Substation Apparatus

For appropriate units see Account No. 45.

General Account II.—Equipment

For new equipment purchased, state on the Completion Report, in the column headed "Description of equipment to which the change is applicable" and on the Record of Property Changes in the column headed "Remarks," the important "specialties" included in the equipment as purchased. A list of the principal specialties is shown under Accounts Nos. 1, 53 and 54.

Account No. 51.—Steam Locomotives

Steam Locomotives .....Each
State service type (passenger, freight or switch), kind, Whyte symbols, cylinder size, saturated or superheated, total light weight engine and tender.
List of Specialties:
1. Axles, Vanadium Steel, finished weight.
   Axles, heat treated and hollow bored, finished weight.
2. Cylinders, Hobart Alfree.
3. Frames, Vanadium Steel, finished weight.
4. Rods, Vanadium Steel, finished weight.
5. Springs, Vanadium or Crucible Steel, finished weight.
6. Stoker (kind).
7. Tender Frame, Commonwealth.
8. Trailing truck, Commonwealth or Hodges.
9. Valve gear, Baker, Southern or Young.

Account No. 52.—Other Locomotives

Other locomotives .....Each
State kind, drive number, of units coupled, and total weight (current and voltage, if electric.)

Account No. 53.—Freight Train Cars

Freight train cars .....Each
State subclass, body and underframe (steel, wood or composite), capacity, length (over end sills), trucks (kind).
List of Specialities:
1. Cast steel wheels.
2. Steel ends (kind).
3. Roof (kind).
4. Draft gear (kind).
5. Truck Bolsters (kind).
6. Doors (number and kind).
7. Axles (kind).
8. Any departure from usual practice (describe).
9. Insulation (kind).

Account No. 54.—Passenger Train Cars

Passenger train cars.....Each

State subclass, length (over platform end sills), capacity in passenger or pounds, vestibules (kind), kind of lighting, body and underframe (wood, steel or composite), trucks (kind).

List of Specialties:

1. Wheels (kind).
2. Draft gear (kind).
3. Platforms (Commonwealth).
4. Upholstery (kind).
5. Finish (kind).
6. Commonwealth Cast Steel Frame (kind).
7. Insulation (kind).
8. Seats or chairs (kind).
9. Brakes (kind).
10. Lavatories (kind).

Account No. 55.—Motor Equipment of Cars

Motor equipment, complete apparatus (horse power and number of motors) .....Each

Including controllers, switches, breakers, contactor boxes, grid resistances, compressors, collectors, wiring, etc.

Account No. 56.—Floating Equipment

Floating equipment (kind, builder, description).....Each

Account No. 57.—Work Equipment

Work equipment (kind and description).....Each

Each item of work equipment, including appurtenances, shall be appropriately described as in Accounts Nos. 51 to 56, inclusive.

NOTE.—For machines mounted, such as pile drivers, wrecking cranes, etc., state kind, maker and size or capacity.

Account No. 58.—Miscellaneous Equipment

Miscellaneous equipment (kind and description).....Each

Accounts Nos. 71, 72, 73, 75, 76 and 77

No units required for these accounts. Costs shall be shown in the appropriate columns.

Account No. 74.—Stationery and Printing

Stationery and printing.

No units are required for unimportant items.

Important items, such as calculating machines, dictaphones, dictographs, hectographs, typewriters, etc. (kind and description)..Each

Y&S - Yard Tracks & Sidings
Ind. - Industry Tracks, Co.
I.&C. - Industry Tracks, Private
Jt. - Jointly Owned Tracks

NORTH & SOUTH RAILROAD
RECORD OF SIDE TRACKS

Exhibit II
Operating Division.....
Valuation Section.....

Line	Track No.	Description	Length or date of Valuation.....				Changes in Lengths																					
							A.F.E.	Add.	Retire	Length Dec. 31st 19.....				A.F.E.	Add.	Retire	Length Dec. 31st 19.....				A.F.E.	Add.	Retire	Length Dec. 31st 19.....			
			Y.&S.	Ind.	I.&C.	Jt.				Y.&S.	Ind.	I.&C.	Jt.				Y.&S.	Ind	I.&C.	Jt.				Y.&S.	Ind.	I.&C.	Jt.
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Size of form 11" x 17" Binding Margin

Size of form 8½" × 11"

BUILDING RECORD

Exhibit 12

Owning Co. _____ R. & E. Account No. _____ Used For _____

State _____ Val. Sec. _____ County _____ Division _____ Town _____

AFE No's. _____ _____ Date Placed in Service _____ Map Rel. _____ Building No. _____

Present Dimensions _____

Note: Sketch Showing Floor Plan To be Shown On Reverse Side.

DESCRIPTION	COST: Original *		.....Repr. New **	I. C. C. Eng. Report: Repr. New	I. C. C. Eng. Report: Less Depr.
Original Construction* Contract* or Company*					
Construction as of..... .....*					
File Reference:— Plan _____ Inventory Book _____ Page _____					
Bill of Material _____ Contract _____					
Superstructure Complete _____					
Kind _____ Dimensions _____					
Roof — Type _____ Covering _____ Proj. _____					
Walls — _____					
Floor — _____					
Foundation _____					
Platform & Curb _____					
Heating _____					
Lighting _____					
Plumbing _____					
Furniture and Fixtures _____					
Water Lines Outside _____					
Sewer Lines Outside _____					
Accessories —					
Coal and Oil Boxes _____					
Well or Cistern _____					
Toilets _____					
TOTALS					

Insurance Schedule No. _____ Year _____ Bldg. _____ Furniture _____ Other Contents _____

Insurance Schedule No. _____ Year _____ Bldg. _____ Furniture _____ Other Contents _____

* Strike out one which does not apply * Indicate estimated cost by letter "E". ** Estimate based on 1910-1914 Prices.

Size of form 8½" × 11"

BUILDING RECORD

Exhibit 13

Owning Co _____ R. & E. Account No. _____ Used For _____

State _____ Val. Sec. _____ County _____ Division _____ Town _____

AFE No's. _____ _____ Date Placed in Service _____ Map Ref. _____ Building No. _____

Present Dimensions _____

Note:- Sketch Showing Floor Plan To be Shown On Reverse Side

DESCRIPTION	COST				
	Original #		.....Repr. New **	I. C. C. Eng. Report	
				Repr. New	Less Depr.
Original Construction* Contract* or Company*					
Construction as of .....*					
File Reference:— Plan _____ Inventory Book _____ Page _____					
Bill of Material _____ Contract _____					
TOTALS					

Insurance Schedule No. _____ Year _____ Bldg. _____ Furniture _____ Other Contents _____

Insurance Schedule No. _____ Year _____ Bldg. _____ Furniture _____ Other Contents _____

* Strike out one which does not apply. # Indicate estimated cost by letter "E". ** Estimate based on 1910-1914 Prices.

Size of form 8½" × 11"

Exhibit 14

ADDITIONS, BETTERMENTS and RETIREMENTS

AFE No.	Date Placed In Or Retired From Service	Plan File	DESCRIPTION OF PROPERTY CHANGE	ORIGINAL COST	
				Added	Retired
			Reverse Side of Exhibits 12 and 13		

Exhibit 15

NORTH & SOUTH RAILROAD
ROADWAY MACHINE RECORD

Owning Company.....
Division.....

Number of Car or Machine	Name of Manufacturer	Builder Number	Engine Number	Description	Valuation Section	Acquired					Changes By Years							
						A.F.E.	Date In Service	Purchase Price	Other Costs	Total Cost								

Binding Margin

Size of form 8½ x 14"

Size of form 8½" × 11"

Exhibit 16

NORTH AND SOUTH RAILROAD

SHOP MACHINERY AND TOOLS

Name of Owning Company _____ Val. Sec. _____

Name of Machine _____ Shop No. _____

Builder _____

Builder's No. _____ Type No. _____

Seller _____

Cost _____ F. O. B. _____

Req'n. No. _____ Date _____

Order No. _____

Installed At _____ Date _____

Installation Cost - $ _____

Transf. To _____ Date _____ A.F.E. _____

" " _____ " _____ " _____

Retired Value _____ " _____ " _____

Scrap Value _____

Rated Size _____

_____

R.P.M. of Ctrshaft _____

Driven Pulley on Ctrsh. _____

Kind of Drive _____

H.P. Required to Drive _____

Shipping Wt. Lbs. _____

Net " " _____

Bldrs.' D'wg. No. _____

Fdtn. " " _____ Cost of _____

" Size _____

Total Cost of M'ch. & Fdtn. - A.F.E.No. _____ Cost _____

REMARKS: _____

_____

_____

Size of form 4"×6" Exhibit 18

NORTH & SOUTH RAILROAD

RECORD OF.....LOCOMOTIVE NO.....

OWNER.....OPER. CO.....

DESCRIPTION		DESCRIPTION
BUILDER		
BUILDERS NO.		
SET UP AT	SHOPS	
DATE IN SERVICE		
SERVICE TYPE		
KIND		
WHYTE SYMBOLS		
CYLINDER SIZE		
SUPERHEATER		
LIGHT WEIGHTS -		
ENGINE	LBS.	
TENDER	LBS.	DISPOSITION
TENDER CAPACITY		DATE
WATER	GALS.	PLACE
COAL	TONS.	A.F.E. NO.
		CAUSE

FRONT OF CARD

COST TO DATE OF LOCOMOTIVE NO.....

A.F.E. NO.	DATE	DESCRIPTION	NET AMOUNT	
		COST TO DATE AS PER VAL. ORDER NO. 8		

REVERSE SIDE OF CARD

This is a form to be used as a record of changes for each unit of Account No. 51, "Steam Locomotives" and Account No. 52, "Other Locomotives."

It is an index filed by unit numbers and summarizes by A.F.E.'s all completion reports affecting each unit.

Size of form 4" × 6" Exhibit 19

NORTH & SOUTH RAILROAD

FLOATING EQUIPMENT

RECORD OF EQUIPMENT CHANGES No.....

OWNER..... OPER.CO.....

DESCRIPTION	DESCRIPTION
	REMARKS

FRONT OF CARD

A.F.E. No.	DATE	DESCRIPTION	NET AMOUNT	

REVERSE SIDE OF CARD

This is a form to be used as a record for each unit of Account No. 56, "Floating Equipment." It is an index filed by unit numbers and summarizes by A.F.E.'s all completion reports affecting each unit.

Size of Form 4"x6" Exhibit 20

NORTH & SOUTH RAILROAD

MISCELLANEOUS EQUIPMENT

RECORD OF EQUIPMENT CHANGES No.....

OWNER.....OPER. CO.....

DESCRIPTION	DESCRIPTION
	REMARKS

FRONT OF CARD

A.F.E. No	DATE	DESCRIPTION	NET AMOUNT	

REVERSE SIDE OF CARD

This is a form to be used as a record for each unit of Account No. 58, "Miscellaneous Equipment." It is an index filed by unit numbers and summarizes by A.F.E.'s all completion reports affecting each unit.

Size of form 11"×17" Binding Margin Exhibit 22

North & South Railroad
RECORD OF PROPERTY CHANGES

Description of item ..... Unit .....
..... Account No .....
..... Valuation Section .....

AFE No or Reference (1)	Date Completed or Retired (2)	Location & Description (3)	Added Number of Units (4)	Added Cost (5)	Retired Number of Units (6)	Retired Cost (7)	Remarks (8)

"P" PROGRESSIVE
"S" SUPPLEMENTAL
"F" FINAL

NORTH AND SOUTH RAILROAD
RECORD OF PROPERTY CHANGES
SHOWING CHARGES AND CREDITS TO INVESTMENT ACCOUNT

EXHIBIT 23

VALUATION SEC. .....

SHEET.....OF.....SHEETS

LINE	A.F.E. NO (1)	A.F.E. REFERENCE (2)	* (3)	DATE INSTALLED (4)	DATE RETIRED (5)	DESCRIPTION OF WORK (6)	ACCOUNT NO. CHARGE (7)	ACCOUNT NO. CREDIT (8)	ACCOUNT NO. CHARGE (9)	ACCOUNT NO. CREDIT (10)	ACCOUNT NO. CHARGE (11)	ACCOUNT NO. CREDIT (12)	ACCOUNT NO. CHARGE (13)	ACCOUNT NO. CREDIT (14)	ACCOUNT NO. CHARGE (15)	ACCOUNT NO. CREDIT (16)	ACCOUNT NO. CHARGE (17)	ACCOUNT NO. CREDIT (18)	ACCOUNT NO. CHARGE (19)	ACCOUNT NO. CREDIT (20)	ACCOUNT NO. CHARGE (21)	ACCOUNT NO. CREDIT (22)	ACCOUNT NO. CHARGE (23)	ACCOUNT NO. CREDIT (24)
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NOTE-(SIZE OF FORM 17"x22". A CONTINUATION SHEET SHOULD BE USED TO PROVIDE ADDITIONAL "ACCOUNT Nº" COLUMNS AND SHOULD BE OF SAME DESIGN EXCEPT COLUMNS 3,4,5 AND 6 ARE OMITTED.)

BINDING MARGIN

Size 8½" x 11"

Exhibit 24

North & South Railroad Date.....

CONSTRUCTION REPORT OF TIMBER TRESTLES

Bridge No..... Name of Stream(a)..... A.F.E. No.....
Date In Service(b)..... Length(c)..... Val. Section.....
Station: From..... To..... Drawing No.(d).....
Date Work Commenced..... Work Performed by.....
Description of Work(e):.....
.....

Character:..... Open Deck. Treat. Ballast Floor..... Ft. Wide
Pile Framed Bents Mud Sills Pile Stubbs
Signs Water Bbls. Covers Baskets
Helper Posts.....
Helper Bents.....
Framed Posts.....
Shims.....
Sub or Extra Caps.....
Guard Timbers..... G.T. Bolts..... O.G. Cut Washers
Stringers ply 7×15, 7×16, 8×16, 8×18, 8×20, 10×12. O.YP.Cy. F. U. Treat.
Caps 12×12, 12×14, 14×14, 14×16, ... 12, 14, 16, ft. lg. O.YP.Cy. F. U. Treat.
Corbels..... Cross Bracing 3×10, 3×12, 3×16 ..... O.YP.Cy. F. U. Treat.
Posts 12×12..... Sills 12×12.....

Indicate Direction – Number Bents to conform with chainage

BENTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
See Note (f) Panel Length																														
B.R. to Gr.																														
Post Length																														
Piles U. Tr.																														
Caps																														
X-Bracing																														

Cut Off..... Ft..... Average Pile Penetration.....
Longitudinal Bracing, U. Treat.....
B.R. to 1st sash line..... 2nd line..... 3rd line.....
Backwalls, U. Treat..... S.H. Strge..... Ft. long..... Std.....

SUMMARY OF MATERIALS IN PLACE

ITEM	ACCT	UNIT	No. OF PCS.	UNIT PER PC.	QUANTITY	REMARKS (g)
Piling-Posts	6					
"	6					
Guard Timbers	6					
Stringers	6					
Caps	6					
X-Bracing	6					
"	6					
Hardware	6					
Ties	8					
Ballast	11					

Note (a) Show name of Street or Highway if applicable
(b) " first date in transportation service
(c) " overall length between backwalls
(d) If Standard drawing indicate by number
(e) If work involved grading for raise in grade or excavation attach 8½" x 11" form showing profile, cross-sections, etc.
(f) Use another sheet or sheets for long bridges
(g) Show origin of material

Correct:.....

Size 8½" x 11" Exhibit 25

North & South Railroad

Date.....
Val. Sec.....

CONSTRUCTION REPORT FOR WOODEN BOXES & PIPE CULVERTS.

Bridge No.....Name of Stream (a).....A.F.E. No.....
Date In Service.....Size (b).....Length(c).....Drawing No.....
Date Work Commenced.....Work Performed by.....Contract Date.....
Station (center line).....
Description of Work:.....
.....
.....

Profile & Plan of Work

Show Profile Indicating by Dash Lines Old Struct. Repl. if any; also a section of box in detail.
Give Height, Flow Line to B.R. and indicate any grading done in sufficient detail.

SUMMARY OF MATERIAL IN PLACE

ITEM	R & E Acct	UNIT	NO. of P'C'S.	UNITS PER PIECE	QUANTITY	REMARKS (Show origin of Mat'l)
Timber - Kind						
" "						
" "						
Hardware						
Pipe - Kind						

Note (a) Show name of Waterway, Ditch, Cattle Pass, etc. if applicable.
(b) " Inside Dimensions of Boxes, Diameter of pipe or other necessary characteristics.
(c) " Overall Length giving for pipes number of pieces and show under description the Kind of pipe in detail to identify manufacturer's type.

Correct:.....

Size 8½" x 11" Exhibit 26

North & South Railroad

Date .....
Val. Sec. .....

CONSTRUCTION REPORT FOR CONCRETE TRESTLES, ARCHES & BOXES.

Bridge No. ..... Name of Stream (a) ..... A.F.E. No. .....
Date In Service ..... Station: From ..... to .....
Length ..... Type ..... Drawing No. (b) .....
Work Commenced ..... Contractor ..... Date .....
Description of Work .....

UNITS AND MATERIAL	UNIT	NO.	TOTAL	ORIGIN OF MAT'L	UNITS AND MATERIAL	UNIT	NO.	TOTAL	ORIGIN OF MAT'L
Excavations					Slabs: cu. yds.	Each			
Dry	cu. yd				Reinf. Steel	lbs			
Wet	"								
Common	"				Falsework	Bent			
					Piling	lin. ft.			
Piling	lin. ft.				Lumber	MBM.			
					Hardware	lbs.			
					Water Proofing				
Rip Rap	cu. yd				Paint				
					Membrane				
Cofferdam					Walk & Railing				
Lumber	MBM.				Concrete	cu. yds.			
					Steel	lbs			
Hardware	lbs				Lumber	MBM.			
Concrete	cu. yd								

Show Small Scale Profile of Opening

Note: (a) Show name of Street or Highway if applicable.
(b) " all drawing numbers on reverse side if necessary.

Correct .....

Size 8½" x 11"

Exhibit 27

North & South Railroad

Date.....
Val. Sec.....

CONSTRUCTION REPORT FOR STEEL BRIDGES

Bridge No.....Name of Stream(a).....A.F.E. No.....
Date In Service(b).....Length(c).....Drawing No.(d).....
Work Performed by.....Contract Date.....
Station: From.....To.....Date Work Commenced.....
Description of Work(e):.....
.....
.....

UNITS & MATERIAL	UNIT	No.	TOTAL	ORIGIN	UNITS & MATERIAL	UNIT	No.	TOTAL	ORIGIN
Falsework (No. Bents)	Bent				Structural Steel				
Piling	lin ft.				Spans	lbs.			
Lumber	MBM				Towers	"			
Hardware					Wrot Iron	"			
Excavation	cu yds				Cast Iron	"			
Dry	"				Gal. Iron				
Wet	"								
Rock	"								
					Machinery				
Foundation Piling	lin ft.								
Abutment & Piers					Paint (kind)	gal.			
Concrete	cu yds.								
					Timber (Superst)	MBM			
					Ties	MBM			
Cofferdam									
Timber	MBM				Guard Rail				
					Timber	MBM			
Wrot Iron	lbs				Rail	G. Tons			
Cast Iron	"								
Protection Piers					Slabs or Deck				
					Concrete	cu yd			
Rip Rap									
Loose	cu yd				Water Proofing	sq. ft.			
Hand Placed	"				Flooring	MBM			
					Paving	sq. yds			
					Walk & Railing				

Note: (a) Show name of Street or Highway if applicable.
(b) " first date in transportation service.
(c) " in detail point between which measured.
(d) " all drawing numbers involved on reverse side.
(e) If work involved grading for raise in grade or excavation, attach 8½"x11" form showing a profile and cross-sections.
(f) Use two or more sheets for long bridges or complicated work.

Remarks:.....
.....
.....
.....

Correct.....

Size 8½"×11" Exhibit '28

North & South Railroad

REPORT OF RAIL CHANGE

Date.....

A.F.E.....Val. Section.....Division.....

Date Work Commenced.....Date Completed.....

Station: From.....To.....

Description of Work: (a).....

.....

YEAR	(b) Location By Mileage Of New Rail Laid And Rail Retired (Show In Decimals of Mile-3 places)
LEF VAL	
19	
19	
19	
19	
19	
19	
19	
19	
19	
19	
19	

Rail In Track On Date of Valuation and subsequent cycles of changes

Show by Sketch (Not to Scale) Side Track Rail Changes

SUMMARY OF MATERIAL

Item	Unit	No. of Units	Origin	Item	Unit	No. of Units	Origin
Rail				Frogs			
				Switches			
Angle Bars				Guard Rails			
				Derails			
Joints							
Bolts							
Spikes							
Tie Plates							
Rail Braces							
Rail Anchors							
Frogs							

Note (a) Use additional Sheets Where Volume of Work requires it.

(b) Detail of Rail Laid In Turnouts To Be Shown Correct:.....

Size-8½" × 11" North & South Railroad Exhibit 29

REPORT OF BALLAST CHANGE

Date..................

A.F.E.....................Val. Section.....................Division.....................

Date Work Commenced.....................Date Completed.....................

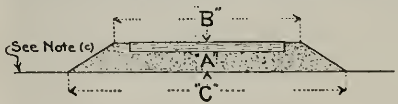
Station : From.....................To.....................

Description of Work:(a).....................

....

Year	Location By Miles of Ballast Changes
I.C.C. Val	
19	
19	
19	
19	
19	
19	
19	
19	
19	
19	
19	
19	

Ballast In Track On Date of Valuation And Subsequent cycles of Changes (b)



Summary Of Ballast Used

Station	Dimensions A	B	C		Area	Distance	Gross Cu. Yds.	Tie Deduction	Net Cu. Yds.	Remarks

Note: (a) Use one sheet to a mile when neccessary and for Ballast "Retired" or "Replaced" use separate forms
(b) Indicate chainage and location of sections taken
(c) Work from assumed sub-grade - Ballast which may have subsided or disappeared should be ignored

Correct.....................

EXHIBIT Nº 30

NORTH & SOUTH R. R.

MILE_____

DISTRICT_____ DIVISION_____ SECTION Nº____ TRACK_____

RECORD OF RAIL IN TRACK AS OF_____19___ RECORDER_____

RAIL Nº	NORTH OR EAST RAIL						SOUTH OR WEST RAIL					
	CHAINING STATION	BRAND	RAIL SECTION	HEAT Nº	LET-TER	CLASS	CHAINING STATION	BRAND	RAIL SECTION	HEAT Nº	LET-TER	CLASS

EXHIBIT Nº 31

NORTH & SOUTH R. R.

HEAT Nº_____

DISTRICT DIVISION SECTION Nº TRACK

NORTH OR EAST RAIL					SOUTH OR WEST RAIL				
MILE	RAIL Nº	CHAINING STATION	BRAND	LET-TER	MILE	RAIL Nº	CHAINING STATION	BRAND	LET-TER

(7) RECOMMENDED PRACTICE TO FOLLOW IN REPORTING THE CONSTRUCTION COST AND PHYSICAL CHARACTERISTICS OF A NEW LINE OR EXTENSION

In reporting the construction costs for new lines or extensions, a report in a complete detail that is comparable to the Interstate Commerce Commission's "Engineering Report" should be made of the cost of each phase of the construction work, and, in addition, all the physical construction features should be faithfully recorded in a uniform way and in a manner easily accessible for future accounting and valuation use.

The mandatory valuation requirements as promulgated by Valuation Order No. 3, Second Revised Issue, do not satisfy all the future demands for detailed construction cost data. The Roadway Completion Report is a statement of units and costs, but underlying this record must be sufficient engineering information to support such costs.

The Interstate Commerce Commission's inventory of railways brought into existence various inventory records, such as grading cross-sections prepared in the field, field notes of all the structural features owned or used by a carrier and forms describing and recording characteristics of other railway property. In a like manner, the construction of a new line or extension should be recorded in detail although much of this information is always prepared in diverse manner during the progress of construction, yet it is not developed and recorded for future use. It can therefore be seen that uniform and consistent methods are necessary for engineering, accounting, depreciation accounting and valuation. Carriers should therefore handle the accounting and engineering records for large projects along the lines set forth in the following.

Form in Which to Report the Information

The carrier should adopt a standard binder and forms so that the entire report of a construction project will be on uniform size sheets, and should arrange that certain maps, profiles, cross-sections and other graphic information should be of uniform sheets to be placed in binders of 8½x11" or 11x17" size so that this information will form an engineering report of the construction and can be filed for use as a detail of the construction, or as a detail of the Investment Account (ledger value) covering the particular construction. This engineering report should be sub-divided in logical subdivisions that can best be accomplished by primary accounts, although a number of general sub-divisions are necessary for general description and history.

(a) General Information and History

The first volume of the report should be an index to all succeeding volumes, describing where detailed construction costs and the engineering data for each primary account will be found. The history of the project from its inception to final construction should be given, including a statement as to the incorporation, financing, general officers, engineering personnel, and other pertinent data. In a graphic form the daily temperatures, precipitation and rainfall should be recorded. Copies of contracts giving the name of contractors, ordinances, franchises and other information should be shown in these volumes.

(b) Completion Maps, Profiles and Charts

The completion map, profile and charts to show the rail, ballast and track laying and surfacing work should be placed in one or more volumes, depending upon the size of the job. These maps should best be shown in sheets of a small size but can be of large size in multiples of the size of the binder, preferably blueprinted on cloth, owing to the unusual wear to which such record will be subjected in future years. The front of the volume should, in addition to the general index, show an index to the map number to avoid undue handling.

(c) Construction Cost Report or Accounting Report

A volume should be set aside to show the cost of construction, either in roadway completion report form, if the project is not large, in which case the detailed cost for each primary account should be reported, separately; in appropriate binder. For a large size job, a volume of summaries showing the construction cost should contain a summary of the primary accounts of Investment in Road and Equipment and Operating Expenses, a balance sheet if a new company and the condensed financial statements. The report dealing with the accounting characteristics should be in sufficient detail to show the complete accounting history of the project; i. e., to show if constructed as a separate corporation in connection with the new line and the complete financial status.

If, in view of the magnitude of the job, it may be desirable to use a completion report or construction cost statement for each primary account, a special form should be printed for that purpose and the following outline gives a description of the detailed reporting:

Account No. 1.—"Engineering"

In a volume for this feature should be shown the details of the engineering costs, giving the costs of recommended preliminary surveys, location and construction. In this statement can be shown the engineering personnel.

Account No. 2.—"Land for Transportation Purposes"

A statement of the construction cost should report each parcel of land on the completion report, by number, and, as a part of the record, a map should be provided showing these parcel numbers so as to definitely indicate the location and legal description of the property involved.

The completion report should show, in addition to parcel number, the deed reference, date, consideration and acquisition costs, and in the same volume of records reporting land details should be a copy of the deed, as under the present-day requirements the Bureau of Valuation, I. C. C., require that right-of-way deeds support any statement of land costs.

Account No. 3.—"Grading"

This account will be a voluminous part of the Engineering Report in view of the necessity of including copies of cross-sections. When construction work starts, provisions can be made to do this by using 20x20" cross-section paper instead of the continuous rolls, and then reducing the sheet by the photostat process to required size. If continuous rolls are necessary the cross-sections should be

platted sufficiently apart to permit of proper reproduction and the platting should clearly show the station number so that any of the grading characteristics can in the future be readily located on the profile and alignment map.

If there is any other work chargeable to Account No. 3, "Grading," such as rip-rap, retaining wall or work of a special nature, sufficient sketches or drawings should be included in the record and indexed so that any item can be quickly located.

Account No. 5.—"Tunnels and Subways"

In the volume or record book under this account should be shown a portion of the profile, indicating the location of tunnel and other drawings that will clearly illustrate quantities in the bore, the lining, drainage, lighting, ventilation and other features.

Account No. 6.—"Bridges, Trestles and Culverts"

An individual completion report should be made for each individual structure and with it should be filed a copy of the exhibits recommended by the Committee, namely, Exhibits 24, 25, 26 and 27, as the case may be. With this particular kind of report should be special drawings, when made, for any individual structure.

Account No. 8.—"Ties"

Account No. 9.—"Rail"

Account No. 10.—"Other Track Material"

These accounts represent the track structure proper and on large projects, individual volumes or record books can be set aside for each, but ordinarily it would be possible to report the track superstructure proper on one completion report, using sub-divisions (Exhibit 5) as a statement of the materials used for each primary account.

The profile should give the chainage pluses of the rail laid on various dates, changes as to weights, rail brand, etc.; also, give similar information with respect to sidings. If this is not shown in this way, the report recommended by the Committee as Exhibit 28 can be used but Exhibit 5 should always be a signed inventory for Accounts No. 8 and No. 10.

Account No. 11.—"Ballast"

In connection with reporting the initial construction for this primary account, it is recommended that the profile show the kind, character and quantity of the ballast applied and the dates, and that typical sections be shown on the form recommended by the Committee, Exhibit 29.

The Completion Report for this account should show, separately, the different kinds of ballast applied and the quantities and costs and should be supported by the physical records outlined above.

Account No. 12.—"Track Laying and Surfacing"

This account being strictly a labor account, reporting the cost of labor, this data should be supported by the completion profile and track chart showing the dates when track laying was completed, and, in addition, should show the

date on which each section goes into transportation service, in order that once service is started the proper distinction between charges to Capital and Operating Expenses can be maintained. Completion Reports showing the cost for "Track Laying and Surfacing" labor should be divided on new construction, in accordance with standard List of Units, recommended by the Committee.

Account No. 13.—"Right-of-Way Fences"

The completion report for this class of work should be compiled in the usual way and in accordance with the recommended List of Units, but the record should contain, in addition to the customary index, a map or graphic record to show the various locations that are fenced, date of construction and a sketch of the type of fence constructed.

Account No. 15.—"Crossings and Signs"

Overhead Crossings

An individual completion report should be made for each structure, supported by forms similar to those provided for bridges (Exhibits 24, 25, 26 and 27) and, in addition, the circumstances may require profile of the crossings which should be put on an appropriate sized sheet adapted for the records.

Grade Crossings

All the grade crossings in a valuation section for new construction should be reported on one completion report, with a proper description, showing the location of each item. The construction profile should show the quantities and a reference to cross-sections to show how the grading quantities were calculated.

Undergrade Crossings

Any work chargeable to this account for undergrade crossings can be reported collectively on one report under this sub-grouping, using forms recommended by the Committee (Exhibits 24, 25, 26 and 27) for this purpose. If, in addition, where there are other characteristics of an unusual nature, such as drainage, electric lighting, paving, etc., Exhibit 5 as recommended should be used, together with appropriate sketches or diagrams.

Accounts No. 16, No. 17 and No. 18.—"Building Work, Water Stations," etc.

In connection with building work, water stations or other structures of a similar kind, one page of completion report should be set aside to each structure in order to build up the proper detail of the Investment Account. Such a report should be supported by a form recommended by the Committee, "Structural Record—Buildings" (Exhibits 12, 13 and 14).

Account No. 26.—"Telegraph and Telephone Lines"

In addition to the completion report for this primary account, a sheet (or multiple thereof) should show graphically the entire cross-arm diagram to indicate the wire locations, other telegraph company locations, etc., as there

is such a continual growth of these facilities that the initial history should be fully reported. A statement of the detail and materials used in the construction can be shown on report recommended by the Committee, Exhibit 5.

Account No. 27.—"Signals and Interlockers"

This section of the construction report should have, in addition to the completion report or statement of construction cost, proper signal drawings and separate sketches or drawings for each interlocking plant, which should be reported separately in the record. The underlying detailed units used should be reported on this Committee's record, Exhibit 5.

Account No. 37.—"Roadway Machines"

Roadway machines, either worn out in the initial construction or turned over to the Operating Department for maintenance purposes, should be reported on this Committee's recommended form—Roadway Machine Record—Exhibit 15. The completion report and the record should show the full detail of the number of the machine manufactured, and company number so that item and accounts will always harmonize.

Account No. 44.—"Shop Machinery"

Any shop machinery and tools purchased for equipping shops and enginehouses should be reported separately for each machine, and the underlying construction record to support the construction report should be this Committee's Exhibit No. 16, "Shop Machinery and Tools."

Other Primary Accounts

The Construction Report involving other primary accounts not enumerated in the foregoing should have separate sub-divisions or they may be reported collectively, provided proper index scheme is prepared so that the physical cost and characteristics of the entire item can be readily located.

The present thought to bear in mind in designing an Engineering and Accounting Report for a large construction project is to build up a comprehensive record for future use, so that the complete history in detail of the project can be available for future use and can be efficiently filed.

An important feature to be borne in mind is proper preservation of the record, as constant handling within a few years may make it useless; therefore exceptional care should be taken in the selection of the paper and the use of cloth blueprints for certain of the folded map records.

The Committee has concluded after investigating this subject that not sufficient attention was paid by carriers to building up for posterity records of the foregoing character; therefore recommend that at the start of all large construction projects, carriers study this question and design reports and records along the lines recommended by the Committee.

Appendix H

(8) METHODS AND FORMS FOR HANDLING THE INTERSTATE COMMERCE COMMISSION'S REQUIREMENTS UNDER ORDER 15100—DEPRECIATION CHARGES OF STEAM RAILROAD COMPANIES

J. H. Hande, Chairman, Sub-Committee; A. M. Blanchard, J. W. Dansey, C. C. Haire.

The promulgation by the Interstate Commerce Commission of its Order 15100—"Depreciation Charges of Steam Railroad Companies" (decided November 2, 1926), created a new set of problems in method and organization and made the above assignment to this Committee a very pertinent one.

On May 6, 1927, the Commission postponed the effective date of the order from January 1, 1928, to January 1, 1929, to give the carriers more time for the "very extensive preliminary work" necessary before the new plan of accounting could be established, and to afford time for a rehearing. The Commission has set November 9, 1927, as the date for this rehearing, and has consolidated with this hearing the matter of general revision of Accounting Rules for Steam Railroads.

In view of these facts the Board of Direction on September 23, 1927, instructed this Committee to do no further work on this assignment.

PROGRESS REPORT OF SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK

Arthur N. Talbot, *Chairman;*
C. B. Bronson,
John Brunner,
W. J. Burton,
Chas. S. Churchill,
W. C. Cushing,
C. W. Gennet, Jr.,
H. E. Hale,
J. B. Jenkins,
George W. Kittredge,
W. M. Dawley, *Vice-Chairman;*
Paul M. LaBach,
C. G. E. Larsson,
G. J. Ray,
Albert Reichmann,
H. R. Safford,
Earl Stimson,
F. E. Turneaure,
J. E. Willoughby,
Committee.

To the American Railway Engineering Association:

The Special Committee on Stresses in Railroad Track, co-operating with a similar committee of the American Society of Civil Engineers and the American Railway Association, presents the following report of progress:

The subject to which the Committee has been giving its principal attention during the past year is the rail joint, its function in the track, and the way in which elements of the design of the joint affect its behavior in the track. The work in the field has included both tests to find the stresses and movements of the joint and its parts and observations on the effect of time and traffic on the condition of the joint in the track. The work in the laboratory has included tests of joints under controlled conditions of loading and reaction, thus giving information on some features of the action of the joint that can not well be learned in the track itself. It is believed that real progress is being made in the investigation of this very complicated problem.

The problem involves the determination of the extent to which the rail splice in its various forms does and should act as a girder continuously with the rail, or possibly only as a hinged connection. It includes such features as the desirable length of splice bar, the effect of shape of bar and of fit against the rail, and the source of some of the forms of fracture found in joint bars. Information is needed on the amount of the tension existing in the track bolts, the range of desirable tension, and the change in amount of tension (increase or decrease) developed in the bolt as the wheel load passes along the rail. Pressures between rail and bar, wear, influence of spring washers, and other topics are also part of the investigation of the problem.

For the purpose of measuring the tension in the bolts of the rail joint a strainmeter was devised which reached around the rail from one side to the other; a reading on the bolt as used or found in the joint and another when the nut had been loosened gave a measurement of the tension in the bolt, the device having been calibrated in a testing machine. This instrument, although its use was slow, gave useful information both in the laboratory and in the track. It can not be used to find the effect of

the passage of a wheel load over a joint in the track. For such purposes new instruments have now been built. Special bolts of nickel steel, designed and built for the purpose and properly heat treated, are used in place of the ordinary track bolt. Drilled axially throughout the length of the bolt is a ¼-in. hole. A rod passes through this hole and is attached to the thread end of the bolt; at the other end it connects with a micrometer gage which is attached to the head of the bolt. Any change in length is indicated on the dial. The instrument is calibrated in a testing machine. For bolts with the nut on the outside of the track a modification of this arrangement is used.

A large amount of data has been accumulated in the tests. The study of the results shows that the problem is very complicated, as would be expected from the presence of so many variables. Again and again the study of the data has been postponed until information on the source of certain phenomena observed or the meaning of certain results could be learned. Even with the ordinary form of joint the amount of the bending moment developed in it at the ends of the rail for a given load varies greatly. The ratio of the bending moment developed in the joint bars to that developed in the full rail away from the joint, under the same conditions of loading, ranges from zero to approximately unity—from taking no bending moment whatever to carrying the full bending moment of the solid rail. This variation is an illustration of the puzzling questions that are being considered in the discussion of the data of the tests. Since the rail joint is an important and essential part of track construction, the more so as loads and rails grow heavier, it is to be hoped that the information obtained will throw light on the action of the rail joint and lead to the formulation of principles needed in the design of the joint and its effect on the upkeep of the track. Progress is being made in the study of the data and in further experimentation. The subject is of such a nature that a partial presentation of the materials collected does not seem feasible at the present time.

The Committee has a number of other questions under consideration.

Respectfully submitted,

The Special Committee on Stresses in Railroad Track,

By A. N. Talbot, *Chairman.*

REPORT OF COMMITTEE VI—BUILDINGS

Frank R. Judd, *Chairman;*
G. A. Belden,
Eli Christiansen,
A. C. Copland,
H. G. Dalton,
F. M. Davison,
W. T. Dorrance,
E. W. Everett,
Hugo Filippi,
E. A. Harrison,
W. H. Hobbs,
J. W. Orrock, *Vice-Chairman;*
A. C. Irwin,
E. A. Johnson,
F. L. Riley,
G. A. Rodman,
O. M. Rognan,
A. L. Sparks,
Arthur T. Upson,
O. G. Wilbur,
A. H. Williamson,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of Manual (Appendix A).
2. Study and report on Specifications for Concrete used in Railway Buildings, collaborating with Committee VIII—Masonry (Appendix B).
3. Study and report on Artificial Lighting for Railway Buildings (Appendix C).
4. Study of methods for improving lighting, ventilation and convenient arrangement of railway structures used in whole or in part for office purposes (Appendix D).
5. Study of rules and regulations for employees of the Building Department, collaborating with Committee XII—Rules and Organization (Appendix E).
6. Study and report on Design and Construction of Water Station Buildings, collaborating with Committee XIII—Water Service (Appendix F).
7. Study of Permissible Grades for Ramps in Railway Buildings, collaborating with Committee XIV—Yards and Terminals (Appendix G).
8. Study and report on Specifications for Buildings for Railway Purposes (Appendix H).
9. Outline of work for ensuing year.

Action Recommended

1. That the changes recommended in Appendix A be approved and the recommended version substituted for that already approved for the Manual.
2. That the subject be reassigned as recommended in Appendix B.
3. That the matter contained in Appendix C be received as information.
4. That this subject be discontinued as recommended in Appendix D.
5. That this subject be continued as recommended in Appendix E.
6. That the matter contained in Appendix F be received as information and the subject reassigned for further study.
7. That the matter contained in Appendix G be received as information.

8. That the specifications contained in Appendix H be received and published in the Proceedings as information and for criticism of the Association and submitted later for publication in the Manual.

Recommendations for Future Work

9. That subjects, 1, 2, 3, 5, 6, 8 and 9 be reassigned for the ensuing year.

Respectfully submitted,

The Committee on Buildings,

Frank R. Judd, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

Frank R. Judd, Chairman, Sub-Committee; G. A. Belden, A. L. Sparks.

At the March, 1927, convention, amendments were made to Articles 12 and 16 of Section 12 of the Specifications for Railway Buildings, covering Structural Steel and Iron, by making provision for temperature stresses. The Committee, after considering the matter, recommends that the amendments to these two articles be deleted and the text restored to its original version. The changes occur in the last paragraph of each article respectively as follows:

Present Form	*Proposed Form*
12. Members subject to stresses produced by a combination of dead load, live load and impact with lateral or longitudinal forces, including temperature changes, may be proportioned for unit stresses 33⅓ per cent greater than those specified in Article 6, but the section shall not be less than that required for dead load, live load and impact.	12. Members subject to stresses produced by a combination of dead load, live load and impact with lateral or longitudinal forces, may be proportioned for unit stresses 33⅓ per cent greater than those specified in Article 6, but the section shall not be less than that required for dead load, live load and impact.
16. Provision shall be made for expansion in structures longitudinally. All expansion provisions shall be figured for 100° Fahr. variation in temperature and for a co-efficient of expansion of 0.0000065 per degree per unit of length. When expansion joints are not used, temperature stresses should be considered in determining section.	16. Provision shall be made for expansion in structures longitudinally. All expansion provisions shall be figured for 100° Fahr. variation in temperature and for a co-efficient of expansion of 0.0000065 per degree per unit of length.

Appendix B

(2) STUDY AND REPORT ON SPECIFICATIONS FOR CONCRETE USED IN RAILWAY BUILDINGS

A. C. Irwin, Chairman, Sub-Committee; W. T. Dorrance, Frank R. Judd.

This Sub-Committee has prepared a Specification for Concrete to be used in Railway Buildings. The specification was not completed in time for submission for criticism to Committee VIII—Masonry. Therefore the specification is not submitted to the Association at this time, and it is asked that the subject be reassigned to permit proper collaboration with the Masonry Committee.

Appendix C

(3) STUDY AND REPORT ON ARTIFICIAL LIGHTING FOR RAILWAY BUILDINGS

G. A. Belden, Chairman, Sub-Committee; O. M. Rognan, W. H. Hobbs.

The following report is submitted as information. It is not the intention to go into technical details as to size of lights, details of installation, etc., but rather to point out general methods of illumination and points to be considered in attacking individual problems.

Artificial lighting originated with crude torches of pine knots and has passed successively through the stages of candles, oil lamps and illuminating gas to its present state, which is almost exclusively by electricity and which is the only means considered in this report.

The subject of artificial illumination is of great importance. It has been estimated that 20 per cent of the total working hours in shops is done under artificial lighting. The proper illumination of shops will insure much greater efficiency and reduce accidents from 20 per cent to 25 per cent. This means direct money saving to the railways. In freight houses, improper lighting causes a large proportion of mis-sent goods, and in storehouses it is the cause of much delay and expense through the selection of the wrong article from the racks.

There are two systems of lighting, namely, general lighting and local lighting. General lighting consists of the equal lighting of all parts of the area under consideration by means of permanent fixtures. Local lighting consists of desk lights and similar movable appliances to illuminate the object under observation.

Local lighting is used chiefly in offices and occasionally in shops. The principal objections are lost time in shifting lights, breakage of lights and the usual marked contrast between the area lighted and the rest of the room. Local lighting serves at times as an auxiliary to a general system.

The three great systems of general illumination are the direct, indirect and semi-indirect. The application of these three systems to meet the requirements of various types of buildings constitutes the chief problem of artificial lighting.

The light circuits should be installed with the service box located at some central point in such a way that all lights throughout the building can be controlled from this point.

The installation of lighting should in all cases be in accordance with local ordinances and also in accordance with the current rules of the National Board of Fire Underwriters. Close co-operation between the Building and Electrical Departments is essential.

SHOPS

The lighting of shops is receiving more attention than ever before and is of great importance. Good lighting is essential to efficiency. Ample general lighting is more desirable than local lighting and there should be no shadows. Pits should be lighted and there should be plenty of floor and wall or post outlets for extension cords where interior work in cars is required. Inasmuch as all ceiling lights have to be above a traveling crane when the shop is so equipped, the crane should have lights on its bottom to prevent a moving shadow.

Yards and runways around shops and enginehouses should also be lighted and the most practical method is by means of flood lights of various sizes according to the area to be lighted. The use of poles for mounting should be avoided as much as possible and the lights mounted on buildings, craneways, etc.

OFFICES AND DRAFTING ROOMS

Offices and drafting rooms should receive in general a different treatment than that accorded shops, warehouses, storehouses, stations and other buildings. For offices and drafting rooms the requirement is an ample intensity of soft, well-diffused light without shadows to enable the close application of the eyes to papers, books and similar objects for long periods without fatigue.

In offices where the position of the eye with respect to the light source must remain practically without change for considerable periods of time, fatigue rather than instant discomfort becomes the determining factor. This means that for best results the choice of units for offices is practically limited to totally indirect and dense glass semi-indirect luminaries. The highly diffused light from the totally indirect type is especially desirable in drafting rooms, where any shadow is very annoying. With indirect or semi-indirect lighting systems it is very essential that the ceiling and walls be light in color and of a dull finish and so maintained.

The lighting system in offices and drafting rooms should be designed to fit special classes of work and to permit flexibility in the arrangement of furniture and generously supplied with outlets for local lighting.

PASSENGER STATIONS

Passenger stations are of two general types—way stations and terminal or larger stations.

Waiting Rooms.—The principal requirements for lighting the waiting room is that of providing adequate illumination to create a cheerful yet comfortable atmosphere throughout and to permit reading with ease for short periods of time.

No set rules can be made for interiors of modern terminal waiting rooms, all possible forms of lighting having been employed with varying degrees of success. Each one requires individual treatment in order that the lighting may not only be in harmony with the architectural features but also comply with good engineering design. A competent illuminating engineer should therefore be called in to assist in planning these elaborate systems.

In modern terminal waiting rooms the lighting frequently consists of batteries of flood lights installed in balconies or concealed around the walls of the room, thus illuminating the ceiling and clere-story walls. The lower portion of the walls, the columns and cornices of the belt course are lighted by electric torcheres or floor standards, or fixtures attached to the seats.

The medium and smaller sized stations do not present as great a problem as the terminal and here a more standardized treatment is possible. The enclosed type of luminarie is becoming more and more popular for these interiors due to their utilitarian value and particularly low maintenance.

In the small type stations it is desirable to provide means whereby this illumination may be reduced during the intervals when traffic is light.

The use of a few high wattage lamps is preferable to the older method of employing a cluster of low wattage lamps, since advantage is taken of the high efficiency of the larger lamps as well as their reduced overall operating costs.

Ticket Offices.—Enclosed or semi-indirect luminaries should be installed in the ticket office to provide general illumination. At the ticket window, operator's table, desks, etc., it is desirable to provide additional local lighting to facilitate speed and accuracy.

Toilet Rooms.—It is generally admitted that light is invaluable as a sanitary precaution, and therefore particular attention should be given to the arrangement of outlets to see that dark areas are eliminated.

Baggage Rooms.—Shallow bowl porcelain enameled steel reflectors with bowl frosted lamps should, in general, be employed in baggage rooms.

Platforms and Exterior Lighting.—These lights should all be operated from a common point of control, and should be so placed as not to be objectionable to crews operating trains or to the handling of passengers.

In the smaller stations, lights should be placed at exterior doors and along the cornice of long buildings, and on posts for lighting platforms throughout their entire length. Shallow dome reflectors and bowl frosted lamps are recommended.

The covered sheds of terminals and umbrella sheds on platforms should have one unit per bay suspended from the roof and mounted high enough to clear loaded trucks.

Subways—Concourses.—For subways and concourses the most satisfactory arrangement of lighting units is to place them at intersection of walls and ceiling—one line staggered with the other. Supplementary lighting should be furnished at the stairs in order that no deceptive shadows be cast, and so arranged that the light will not shine in the eyes of pedestrians going up or downstairs.

Signs and Markers.—Electric guide signs to aid the traveler should be of such type that the lamps are not visible and the design in keeping with other architectural features of the building.

At the more important way stations the main station signs should be illuminated.

FREIGHT STATIONS

Warerooms.—Warerooms should have sufficient illumination over the entire area to provide easy reading of labels and other markings in both horizontal and vertical planes. A straight overhead system of lighting is most satisfactory. Shallow bowl reflectors and frosted lamps are recommended and they should be placed close to the ceiling or at least 10 feet above floor to avoid loaded trucks and should be so located as to avoid shadows from beams, trusses, etc. Vaporproof equipment should be provided for cold storage rooms to prevent corrosion of such equipment.

Loading Platforms.—Loading platform lighting should provide sufficient illumination for easy and quick movement of freight to and from cars. Outlets for extension cords to cars should be provided recessed along the edge of platform or in case of covered platforms be placed along the edge of canopy. When there are a number of parallel tracks, the extension cords should be fitted with combination socket and plug receptable so that additional cords may be attached for each succeeding track.

Freight Offices.—Lights in offices should be as recommended for offices and drafting rooms.

COAL CHUTES

To avoid personal injury to workmen and for the saving of coal, chutes should be well lighted throughout the interior of the structure. Exterior lights should be placed at the coaling aprons and at ladders and stairways.

Appendix D

(4) STUDY OF METHODS FOR IMPROVING LIGHTING, VENTILATION AND CONVENIENT ARRANGEMENT OF RAILWAY STRUCTURES, USED IN WHOLE OR IN PART FOR OFFICE PURPOSES

A. L. Sparks, Chairman, Sub-Committee; Eli Christiansen, F. M. Davison, E. A. Harrison, A. C. Copland.

The work assigned to this Sub-Committee largely overlaps work which has been done or is being done by other sub-committees. The lighting of railway buildings is included in the work of Sub-Committee No. 3, as reported in Appendix C of this report. The ventilation of buildings including offices was covered by a Sub-Committee in 1925 and reported in Volume 26, page 466, Appendix B, of the Proceedings. There is such divergence in the grouping of offices on account of the operating requirements of the various railways, and local conditions are such important factors that it is not thought advisable to make any recommendations upon this item.

This Sub-Committee therefore recommends that this subject be discontinued.

Appendix E

(5) STUDY OF RULES AND REGULATIONS FOR EMPLOYEES OF THE BUILDING DEPARTMENT, COLLABORATING WITH COMMITTEE XII—RULES AND ORGANIZATION

W. T. Dorrance, Chairman, Sub-Committee; G. A. Rodman, E. A. Johnson, A. H. Williamson.

It is noted in the current report of Committee XII that they have not as yet considered the subject of maintenance of buildings and therefore, it is recommended that this subject be reassigned for collaboration with them.

Appendix F

(6) STUDY AND REPORT ON DESIGN AND CONSTRUCTION OF WATER STATION BUILDINGS, COLLABORATING WITH COMMITTEE XIII—WATER SERVICE

Eli Christiansen, Chairman, Sub-Committee; Hugo Filippi, W. H. Hobbs, O. M. Rognan.

The following is submitted as a progress report for printing in the Proceedings.

The Sub-Committee has predicated its report on the report of the Water Service Sub-Committee, found under Appendix H, Bulletin 281, page 236, and offers the following information in amplification of the above report.

The following classes of buildings are in general use for water station service:

(1) Pumping plants operated by steam.
(2) Pumping plants operated by internal combustion engines.
(3) Pumping plants operated by electric motors.
(4) Pumping plants at deep wells operated by steam, internal combustion engines, electric motors, or compressed air.
(5) Water treating plants.
(6) Pumper's cottages.

Steam Plants.—While steam plants are to a large extent being supplanted by other forms of power, their use in some locations is still very desirable, particularly at junctions and at other points, for the purpose of supplying steam for coach heating and for secondary buildings, in addition to their use for water service.

The size of buildings now in use for this purpose has been found to vary considerably, ranging in size from 16'x20' to about 16'x28', with sidewalls from 8' to 14' high.

Internal Combustion Engine Plants—Small Units.—The size of pumphouse required for this type of plant is directly related to the kind and capacity of equipment used and has been found to vary from about 12'x16' to 14'x28', with sidewalls from 8' to 12' high.

Electrically Operated Plants.—Buildings for this type can generally be made smaller in size than for internal combustion engine plants. A building from 10'x10' upward, seems to find common use.

Large Pumping Plants.—This type of plant, being usually found at large terminals or at important intermediate points, requires special study. In general, such buildings should be of substantial construction and meet all special local requirements.

Pump Houses for Wells.—Buildings for this purpose are generally not over 10'x10', but houses 10'x20' and larger are used, depending on the capacity of the plant and the type of power used. A derrick frame, extending from 20'x35' above the roof, should be provided. This frame may rest on the building or on a separate foundation.

Buildings for Water Treating Plants.—Buildings of this type are generally of frame construction. The size of building required is directly related to the method of treatment and the required capacity of the plant.

GENERAL DETAILS OF CONSTRUCTION

Foundation.—Owing to the proximity of water station buildings to a body of water, the ground is frequently unstable and particular attention should be paid to the design of the foundation so as to prevent unequal settlement. The foundation should preferably be of concrete, suitably reinforced and waterproofed if necessary.

The concrete work should extend at least 6 inches above the floor line, and sufficiently below frostline to insure good bearing soil.

Floor.—Floors should preferably be of concrete laid on suitable soil or fill, sloped for drainage, and reinforced where necessary.

Pits.—Pits and wells are built of brick or concrete, the latter being preferable. Where subject to hydrostatic pressure, these structures should be thoroughly reinforced and waterproofed, particularly when below high water level.

Frame Walls.—Frame walls should be constructed with studding of suitable size and spacing. In northern climates the outside of the building should be sheathed and sided, with a layer of waterproof paper between the sheathing and siding.

In southern climates, one thickness of wood siding is usually sufficient, and corrugated galvanized iron siding may be used, if preferred.

Interior Lining.—Lining of wood or other suitable material should be provided where climate or other local conditions warrant its use. In some cases an asbestos wainscoting 5 feet high has been provided to reduce fire hazard.

Ordinarily, water service buildings do not require a ceiling, the roof serving this purpose.

Masonry Walls.—Where local or economic conditions warrant, brick, concrete, hollow tile, cement blocks or other fire-resisting material should be used for walls. Unless local ordinances govern, all masonry walls, other than of concrete, should preferably be not less than 9 inches in thickness, properly stiffened with cross walls or pilasters or both, especially in the case of extremely long or high walls.

Steel Walls.—Corrugated galvanized iron siding may be used either on wood framing or, as in the case of fabricated steel buildings, on standard or special rolled sections. If used on steel studding, special provision should be made for attaching furring strips on the inside for properly nailing the interior lining.

Roof Framing.—On frame buildings, the rafters should be of wood of suitable size and spacing. The roof boards should be of dressed material covered with fire retardent material.

Where climatic conditions permit, corrugated galvanized iron may be used in lieu of roof boards and roofing. Either of these types may be used for brick buildings but if fire-resisting construction is used, the roof slab should preferably be of concrete covered with composition roofing and insulated.

Ventilation.—Provision should be made in the roof construction for proper ventilation, especially where internal combustion engines are used.

Windows.—At least two check rail windows of suitable size should be provided in the boiler and pump rooms. These may be of either frame or steel, but in fire-resisting construction, steel sash with glazing angles and wire glass are recommended. Windows permitting at least 25 per cent ventilation should be provided, with sufficient glass area to give adequate natural lighting to the interior. In extremely cold climates, the steel sash should be provided with weather stripping or made tight by double glazing.

Doors.—One or more doors should be provided to permit entrance and convenient handling of machinery in and out of the building. For fire-resisting buildings, use should be made of steel, kalamein or tin-clad doors.

Lighting.—If local power supply is available, electric lighting should be provided and installed in accordance with Underwriter's rules. Base plugs should be installed to allow the use of extension cords.

Heating.—Stove heat is perhaps most generally used, but where local steam supply is available, radiators may be installed. In northern climates particular attention should be paid to the insulation and protection of the building to reduce radiation losses.

Painting.—The exterior surface of all frame and steel buildings should be painted three coats. Doors and windows, whether of wood or steel, should be painted on both sides. Interior painting other than for doors and windows is optional and should be decided in each case.

Platforms, Coal Bins, etc.—Provide these items as may be required for the particular building in question.

Conclusions

Sufficient study and investigation has not yet been made to justify any definite conclusions and this report is being offered only as information and as a progress report on the subject. A more detailed investigation is being made to correlate all available standard plans and if possible, recommendations as to design of buildings, specific details, etc., will be made to the next convention.

It is also proposed that the Sub-Committee prepare typical or standard plans for the several types of buildings and structures included under this assignment.

Appendix G

(7) THE STUDY OF PERMISSIBLE GRADES FOR RAMPS IN RAILWAY BUILDINGS; COLLABORATING WITH COMMITTEE XIV—YARDS AND TERMINALS

O. G. Wilbur, Chairman, Sub-Committee; H. G. Dalton, E. W. Everett, F. L. Riley.

The following is submitted as information for printing in the Proceedings.

General.—The study of ramps for railway buildings is a subject upon which, although there is only a limited amount of data available, the results obtained from the major installations studied are of sufficient scope to indicate a broad field for the effective application of ramps in railway building construction.

Pedestrian Ramps.—The ramps for pedestrian use in the Grand Central Station, New York City, have been in service over a sufficient number of years to have passed beyond the experimental period and are therefore cited in this report as examples of good practice. The Chicago Union Station, a terminal of more recent construction, is also referred to because of the satisfactory results that are being obtained from their ramp construction.

In designing the ramps for the New York Central Terminal, experimental ramps were built which were ascended by persons carrying bags and other burdens. As a result of these studies the plans were prepared for construction of ramps in general not exceeding a 10 per cent maximum grade. This grade was used on ramps from both the Upper and Lower Level Platforms to the Concourse, the Upper Level ramps being about 30 feet in length and the Lower Level ramps about 135 feet in length, but in general the grades are under 10 per cent. There is one ramp located at a pedestrian entrance to the station which is on a grade of 11.6 per cent.

The Grand Central Terminal ramps are all of structural steel construction with reinforced concrete slab. The first of these ramps placed in service were surfaced with cement with carborundum troweled into the wearing surface. This surfacing was done under most trying conditions and in extremely cold weather, but the work has stood up exceedingly well under traffic. Ramps through the building which were originally surfaced with clay tile when first laid had sufficient abrasive qualities to prevent slipping, but with continued traffic became slippery to such an extent that on those ramps where the traffic was heaviest it became necessary to replace the tile with other material. On the 11.6 per cent ramp a non-slip patented Solry cement tile was laid. This tile was cast of a size 6 in. by 6 in. about one inch in thickness and bedded in cement mortar. On one of the wide ramps connecting the upper and lower levels Solry cement mortar surfacing about one inch thick was applied and rubbed with a rubbing machine similar to that used for surfacing terrazzo and marble floors. The result has been exceptionally good. The floor is smooth, free from cracks and has sufficient abrasive qualities to prevent slipping without making walking uncomfortable.

Several other ramps in the Terminal have been resurfaced with different material from time to time. Kingwood stone, Potsdam sandstone and tarvertine having been used. These materials, while sufficiently abrasive to prevent slipping (with the possible exception of tarvertine, which has not been on ramps in excess of 6 per cent grade) wear out rather rapidly under heavy traffic.

In the Chicago Union Station the ramps from the passenger platforms to the concourse are on a 6.75 per cent grade and are 70 feet long. The grade of the ramps from the concourse to the street level, used mostly by commuters, is 11 per cent and the length approximately 182 feet, giving a total lift between the street and the concourse floor of 20 feet. The ramps of 6.75 per cent grade are constructed of concrete with carborundum grains sprinkled over and troweled into the top of the mortar coat. Twelve pounds of carborundum grains consisting of equal portions of sizes 30, 40 and 60 grains were used to the 100 square feet of platform. The 182 ft. ramp of 11 per cent grade is surfaced with a so-called art marble tile, which is a composition of marble chips, sand, alundum and cement. These tiles are 3⅞ in. wide by 12 in. long and are laid with a transverse joint every 4 inches to prevent slipping. The face of the tiles are laid at a slight inclination to the grade of the ramp, with up-hill edge beveled. This method of laying provides a very effective foothold every four inches and on the ramps referred to there have been no accidents since the station was put in service, although they lead directly to the street and are subject to tracking of snow.

A recent traffic count in the Chicago Union Station would seem to indicate that these ramps are used in preference to stairways, which are adjacent to them, in the ratio of two to one, and it is estimated that three million people have used the 11 per cent ramp without an accident since the opening of the station.

Trucking Ramps.—The 30 ft. ramps of 10 per cent grade in the Grand Central Terminal referred to in the second paragraph under the caption "Pedestrian Ramps" are also used by electric trucks in trucking baggage. Although these ramps are on a 10 per cent grade, the trucks do not seem to have any particular difficulty in ascending them because they are only about 30 ft. in length; however, when consideration is given to battery capacity, weight of truck and pay load carried, it has been the experience of tractor and truck manufacturers that the operation of electric trucks becomes uneconomical on 10 per cent grades unless the ramp is short.

Hand trucking on ramps whose grades exceed 10 per cent is very difficult, except for small hand baggage trucks, unless the length of ramp is very short.

The grade of the baggage, mail and express ramps in the Chicago Union Station is 6.75 per cent and their length is 180 feet, making a total lift from basement to platform of 12 feet. The wearing surface on these ramps is asphalt mastic and no difficulty in operation is encountered either with a burden-carrying electric truck or with an electric tractor pulling as many as three trailers loaded with the average load of baggage, mail and express. Occasionally, when the surface of the ramp is wet, the ramp becomes slippery and requires sanding.

The Chicago, Burlington & Quincy Railroad have recently constructed a three-story, reinforced concrete general storehouse at Aurora, Ill., which is equipped throughout with ramps for tractor and trailer service, no elevators being provided in the building.

In this building the ramps are constructed on a 7 per cent grade, the roadways being divided into two lines, one for upward and one for downward traffic. The ramps are surfaced with asphalt blocks and after being in service over a year are found to be giving complete satisfaction.

Summary

1. Ramps for pedestrian use surfaced with a non-slip material constructed with gradients as high as 11.6 per cent are being used in some large modern stations, but 10 per cent is recommended as a working maximum.

2. Ramps for trucking service, either hand or power, develop difficult and uneconomical operation when the grade exceeds 7 per cent unless the distance traversed is very short.

3. Results obtained from operation of ramps on these grades have been exceedingly satisfactory and it is felt that a great measure of the successful operation of the terminal facilities mentioned in this report, in handling people, baggage, mail and express, is due to the use of ramps and to the elimination of elevators, stairways, conveyors, etc.

Appendix H

(8) STUDY AND REPORT ON SPECIFICATIONS FOR BUILDINGS FOR RAILWAY PURPOSES

J. W. Orrock, Chairman, Sub-Committee; W. T. Dorrance, A. C. Irwin, Arthur T. Upson, A. L. Sparks, Frank R. Judd.

Under this heading it is the intention of this Sub-Committee to supplement the specifications already adopted by furnishing paving and flooring specifications as follows:

Paving (Exterior)	*Flooring (Interior)*
No. 21-A—Brick	No. 21-B—Brick
No. 22 —Concrete	
No. 23-A—Wood Block	No. 23-B—Wood Block
No. 24-A—Native Sheet Asphalt	No. 24-C—Native Asphalt Mastic
No. 24-B—Petroleum Sheet Asphalt	No. 24-D—Petroleum Asphalt Mastic
No. 25-A—Asphalt Block	No. 25-B—Asphalt Block
No. 26-A—Macadam	
No. 26-B—Asphalt Macadam	

At this time specifications Nos. 21-A, 21-B, 22, 23-A, 23-B, 25-A, 25-B, 26-A and 26-B are submitted for publication in the Proceedings as information and for criticism of the Association. The full series will be submitted later for publication in the Manual. The specifications submitted at this time follow.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 22

Concrete Pavements and Foundations

1. General

The contractor shall furnish all labor, material, tools and equipment necessary to entirely complete the work as herein specified and shown on the drawings.

2. Description

The pavement shall consist of a subgrade and one course of concrete of the thickness shown on drawings, together with a curb and gutter as shown or indicated.

3. Grading and Subgrade

The grading shall be completed to the proper subgrade elevation to permit the specified thickness of pavement to be laid to bring the finished surface of the pavement to the established lines and grades.

The bottom of the excavation or top of the fill, when completed, shall be known as the subgrade.

The subgrade shall be constructed to have, as nearly as practicable, a uniform density throughout its entire width. It is not intended that the rolling shall be continued beyond this point, as the purpose of rolling is not to produce a subgrade that cannot be further compacted but to produce a uniformly compacted subgrade.

All soft, spongy or yielding spots and all vegetable or perishable matter shall be entirely removed from the subgrade and the space filled with suitable material.

Where a fill is required to bring the subgrade to the required elevation, it shall be made in layers not to exceed six (6) inches in thickness and each layer shall be thoroughly rolled or tamped.

Compression of the subgrade material shall be accomplished with a self-propelled roller weighing not less than five (5) tons. Hand tamping, where directed by the engineer, shall be done with a tamp weighing not less than fifty (50) lb. and whose face does not exceed one hundred (100) square inches in area.

All hauling shall be distributed over the width of the subgrade so far as practicable, so as to leave it in a uniformly compacted condition.

Wherever the subgrade extends beyond the lateral limits of an old roadway or wherever an old gravel, macadam, or other hard compacted crust comes within 6 in. of the elevation of the finished subgrade, such old roadway or crust shall be ploughed, loosened or scarified to a depth of at least 6 inches and the loosened material redistributed across the full width of the subgrade, adding suitable material, when necessary. Neither fine nor coarse aggregate shall be deposited upon the subgrade before it has been shaped and brought to the true finish.

All depressions and ruts developing under traffic on the subgrade or in connection with rolling, shall be filled with suitable material.

Shoulders, berms or ridges of earth or other material that will interfere with the immediate discharge of water from the subgrade to the side ditches shall not be left on the subgrade.

Special treatment may be required for certain subgrades such as sand, gumbo, adobe and other materials, which cannot be satisfactorily prepared by the methods specified in the foregoing paragraphs.

After being prepared in the manner above specified, the subgrade shall be so maintained until the concrete pavement has been placed thereon.

Surplus excavated material shall be disposed of by the contractor. The contractor shall remove all obstructions such as trees, stones, blocks, etc.

4. Curbing

Concrete curbing shall be built according to details shown on drawings.

5. Concrete Materials and Workmanship

All cement and concrete materials and workmanship shall comply with the specifications for concrete as given in Section No. 4 of these specifications. Not more than five (5) gallons of water shall be used to each sack of cement.

6. Joint Filler

Joint filler shall consist of prepared strips of fiber matrix and bitumen, or a uniform mixture of fibre and bitumen, or a combination of both, containing not more than 25% by weight of inert material, having thickness of . . . . inches and width equal to . . . . inches greater than the thickness of the pavement at any point. The bitumen used in manufacture of the joint filler may be either tar or asphalt of a grade that will not become soft enough to flow in hot weather nor brittle in cold weather.

7. Forms

Forms shall comply with the specifications for concrete as given in Section No. 4 of these specifications. Wooden forms shall be straight, dressed on at least one side, not less than 2 inches (nominal) in thickness and equal in width to the depth of the concrete which is to be placed against them. Wooden forms shall be held in place by stakes driven into the ground along the outside edge at intervals of not more than 6 feet, two stakes being placed at each joint. The forms shall be firmly nailed to the side stakes and braced to resist the pressure of the concrete or the impact of tamping.

Metal forms shall be of shaped sections. They shall be straight, have a depth equal to the depth of the concrete to be placed against them and sufficient strength to resist without springing the working strains to which they are subjected.

8. Joints

The joints to be formed shall be transverse or longitudinal. They shall be tested with a 10-ft. straightedge during and after finishing and any irregularities in the surface shall be immediately corrected.

In pavements with integral curb and gutter, joints shall be continuous in a straight line through pavement and curb.

Manhole and catchbasin covers and all other fixed objects in the pavement shall be separated from the concrete by joint filler.

All joints shall extend through the entire thickness of the pavement; shall be perpendicular to the surface of the pavement, and be edged to a radius of ¼ in.

9. Expansion Joints

Transverse expansion joints shall be placed across the pavement perpendicular to the center line. They shall be ⅜ inch wide and spaced 35 ft. apart between intersections. A bulkhead cut to the exact cross-section of the pavement shall be securely staked in place at right angles to the center line and surface of the pavement. The premolded joint filler shall be cut to conform to the cross-section of the pavement and in lengths equal to the width of the pavement, except that strips equal in length to half the width of the pavement may be used when laced or clipped together at the center in a workmanlike and effective manner. The joint filler shall be placed against the bulkhead and held in position by pins on which there is an outstanding lug. Before the bulkhead is removed concrete shall be deposited on both sides of it. After the concrete has been brought to the proper crown the bulkhead shall be removed by lifting it slowly from one end and replacing it with concrete as it is lifted, so that the joint filler will be left in the correct position.

Before the pavement is opened to traffic the joint filler shall be trimmed off to a uniform height of ¼ inch above the surface of the pavement.

Expansion joints in intersections shall be located as shown on the plans or as directed by the engineer.

When expansion joints are made at the end of the day's work they shall be formed by finishing the concrete to the bulkhead, placed as before specified. When work is resumed the joint filler shall be placed against the hardened concrete and held in position by pins until fresh concrete is placed against it.

Longitudinal expansion joints shall be formed by placing the filler against the form, bulkhead, curb, or adjacent structure and placing the concrete against it. The filler shall extend the full depth of the pavement, and be flush with the pavement surface.

10. Longitudinal Dividing Joint

When the whole width of the pavement is placed in one operation, and longitudinal joints are used they shall be formed by embedding in the pavement a strip of galvanized or painted 18 gauge, corrugated sheet metal 1 inch less in depth than the depth of the pavement at the joint. The metal shall be accurately staked to line and grade by means of pins driven vertically through holes provided for that purpose at not more than 4 feet intervals. The pins shall be of mild steel ¼ inch in diameter and at least 15 inches long, and shall be left in place. The metal strips may be of any length. Punched or cut holes shall be provided in the strips at 5 foot intervals to receive ½ inch round tie bars embedded 2 feet on each side of joint. The metal shall be carefully placed in the proper location and be vertical when the concrete is deposited about it.

When the pavement is built in successive longitudinal strips, longitudinal joints shall be formed by painting the edge of sections first built with a bituminous paint and depositing the concrete in adjacent section against the painted edge.

11. Placing Reinforcement

Steel fabric reinforcement when called for on the drawings shall be placed 2 inches below and parallel to the finished surface of the pavement unless otherwise indicated. Fabric shall extend to within 2 inches of sides and ends of slabs. All laps of fabric sections shall be not less than three-fourths of the spacing of members in the direction lapped.

Steel bar reinforcement when called for on the drawings shall be placed 3 inches below the finished surface of the pavement unless otherwise indicated. Transverse bars shall extend to within 2 inches of the margins of the pavement. Bar reinforcement shall be placed and securely supported in correct position before any concrete is laid. All intersections of longitudinal and transverse bars shall be securely wired or clipped together to resist displacement during concreting operations.

12. Placing Concrete

Concrete shall be placed only on a moist subgrade, but there shall be no pools of standing water. If the subgrade is dry, it shall be sprinkled with as much water as it will absorb readily.

The mixed concrete shall be deposited rapidly on the subgrade to the required depth and for the entire width between longitudinal joints in successive batches and in a continuous operation without the use of intermediate forms or bulkheads between joints. While being placed, the concrete shall be vigorously sliced and spaded, with suitable tools, to eliminate voids or honeycomb pockets. The concrete shall be especially well spaded and tamped against forms, bulkheads, curbs and gutters.

When the concrete is placed in two layers to permit the use of steel fabric reinforcement, the first layer shall be roughly struck off with a template or lute at the correct elevation to permit placing the reinforcement in the specified position. The concrete above the reinforcement shall be placed within 15 minutes after the first layer has been placed.

13. Finishing

(a) Striking Off.—Between intersections the concrete shall be brought to the specified contour by means of a screed or template, fitted with handles and weighing not less than 15 lb. per lin. ft. This template may be of steel, or of wood shod with steel. It shall be shaped to the contour of the pavement and have sufficient strength to retain its shape under all working conditions.

The template shall rest on the side forms, curbs or gutters and shall be drawn forward with a sawing motion. At transverse joints the template shall be drawn not closer than 3 feet toward the joint and shall then be lifted and set down at the joint and drawn backward away therefrom. Surplus concrete shall then be taken up with shovels.

(b) Tamping.—After the concrete has been struck off, the template shall be used as a tamp. In this operation one end of the template shall rest on the side support, while the other is lifted and dropped, advancing at such a rate that the whole pavement is struck at least once. The opposite end shall then be lifted and dropped and advanced in the same manner. In no case shall either end be advanced more than 1 foot ahead of the other.

(c) Luting.—Instead of screeding with a template as specified above in (a), the correct pavement contour may be secured by the use of a lute. In that case steel grade stakes provided with lugs shall be driven into the subgrade with the top of the lugs accurately set at the elevation for the finished pavement. These stakes shall be set at intervals of 10 ft. along the subgrade and in a straight line perpendicular to the center line of the pavement, one at the center line and one at each quarter point and at as many additional points as the engineer may direct. The concrete shall then be spread to the elevation indicated by the stakes.

(d) Imperfections.—Immediately after the screeding or luting has been completed, the surface shall be inspected for high or low spots and any needed corrections made by adding or removing concrete. Rough spots shall be gone over with a long handled float and worked to proper contour and grade. The entire surface shall then be floated longitudinally, with a float board not less than 16 ft. long and 8 in. wide. This float board shall have convenient plow-handles at each end. It shall be operated by two men, one at each end, each man standing on a bridge spanning the pavement. The lower surface of the float board shall be placed upon the surface of the concrete with the long dimension parallel to the center line of the pavement. The float shall then be drawn back and forth in slow strokes about 2 ft. long, and advancing slowly from one side of the pavement to the other. The purpose of this operation is to produce a uniform even surface on the concrete, free from transverse waves. The two bridges on which the workmen stand should be placed about 18 feet apart when the length of the float is 16 feet. When the entire width of the pavement has been floated in this manner from one position of the bridges, they shall be moved ahead about 12 feet so that the next section to be floated shall overlap the one previously floated from 3 to 4 feet.

Cement mortar gathered from the surface of the concrete already placed shall not be used in filling boot tracks or stony areas, but such imperfections shall be dug out and refilled with concrete to the depth of the reinforcing and worked smooth. No person shall then be allowed to walk over the area so completed.

(e) Belting.—The concrete shall be finished by using a belt of wood, canvas or rubber, not less than six nor more than 12 inches wide, and at least 2 feet longer than the width of the pavement. The belt shall be applied with a combined crosswise and longitudinal motion. For the first application vigorous strokes at least 12 inches long shall be used, and the longitudinal movement along the pavement shall be very slight. The second application of the belt shall be immediately after the water sheen disappears, and the stroke of the belt shall be not more than 4 inches and the longitudinal movement shall be greater than for the first belting.

The contractor shall provide a suitable split float or split roller having a slot to fit over expansion joints. This device shall be so arranged as to float the surface for a width of at least 3 feet on each side of the joint simultaneously. This device shall be used in such manner as to produce a true surface across the joint. Edges of the pavement, at joints and side shall be tooled for a width of 2 inches, the corners rounded to a radius of ¼ inch.

14. Curing and Protection

The contractor shall provide a sufficient amount of burlap or canvas to cover all the pavement laid in any one day's maximum run. Burlap or canvas cover shall be made up in sheets 12 ft. wide, and 4 ft. longer than the width of the pavement. Burlap or canvas cover shall be placed on the concrete immediately after the final belting, and shall then be sprayed with water in such a manner that the surface of the pavement will not be damaged. Burlap or canvas cover shall be kept continuously moist by spraying until the concrete has taken final set.

As soon as it can be done without damaging the concrete, the surface of the pavement shall be covered with not less than 2 in. of earth or 6 inches of hay or straw. This cover shall be kept continuously wet by spraying for 10 days after the concrete is laid.

The ponding or the spraying method of curing may be used when and as approved by the engineer. After 14 days, the earth or other cover may be removed. After 30 days the contractor may use a mormon or a fresno scraper to remove the cover, except that scrapers shall not be used within 1 ft. of expansion joints. Cover within 1 ft. of expansion joints must be removed by hand. Road machines or blade graders of the 2 or 4 wheel type shall not be used for removing the cover.

After the cover has been removed or ponds emptied and dikes removed, the entire surface of the pavement shall be swept clean and free from dirt and débris. Horse or motor drawn sweepers shall not be operated on the pavement till 20 days have elapsed after the concrete is placed.

15. Prohibition of Traffic

The contractor shall provide and maintain substantial barricades across the pavement, with suitable warning signs by day and by night, to prevent traffic of any kind upon the pavement before it is 20 days old.

16. Adjusting Existing Structures

Manhole and catchbasin covers, valve boxes and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the surface of the pavement.

17. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of said improvements to be of such quality and character as to insure the same to be free from all defects and to remain in continuous

good order and condition satisfactory to the Engineer of the Railroad Company for a period of two (2) years as above set forth. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work as the Engineer of the Railroad Company may direct without additional charge or cost to the Railroad Company.

In case the paving, or any part thereof, is on public property where city ordinance or other ruling requires a maintenance bond, the contractor shall furnish within ten (10) days after the contract is let, a good and satisfactory bond to the amount as stated in the general contract to maintain that portion of the work on said public property as covered by this contract at the finished line and grade for a period of years as required by ordinance or ruling.

18. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section No. 1 of these specifications shall be considered to apply with equal force to this specification.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 23-A

Creosoted Wood Block Pavements

1. General

The contractor shall furnish all labor, materials, tools and equipment except as otherwise noted, necessary to complete entirely the creosoted wood block pavement as hereinafter specified, and as shown or implied on the drawings.

2. Description

The pavement shall consist of a subgrade and concrete foundation and a wearing course of creosoted wood blocks laid over either a bituminous paint coat, a mortar bed or a bituminous mastic cushion, applied to such foundation.

3. Grading, Subgrade and Foundation

The grading, subgrade and foundation shall be constructed in accordance with the current specification of the A.R.E.A. for Concrete Pavements, except, however, joints shall be omitted and the concrete finished to a smooth even surface exactly the depth below the finished pavement, corresponding to the combined depth of the wood block and the thickness of the paint coat, mortar bed, or mastic cushion to be used.

4. Curb and Gutter

The curb or the curb and gutter shall be built in the location and to the elevation, sizes and cross-section shown on drawings.

All cement and concrete materials and workmanship shall comply with the specifications for Concrete as given in Section No. 4 of these specifications.

5. Kind of Blocks

The wood from which the blocks are to be manufactured shall be Douglas fir, Norway pine, southern yellow pine, tamarack, western larch or other suitable wood approved by the Engineer. Blocks from only one kind of wood shall be used in any one contract, and they shall first be treated with a preservative as hereinafter specified.

6. Quality of Blocks

The blocks must be sound and well manufactured, square butted, square edged, free from unsound or loose knots, holes, shakes, checks or other defects that will impair their usefulness for pavement.

In Douglas fir or southern yellow pine, the number of annual rings in the 1-inch which begins 2 inches from the pith of the block shall not be less than six, measured radially; provided, however, that blocks containing between five and six rings in this inch shall be accepted if they contain 33⅓ per cent or more of summerwood. In case the block does not contain the pith, the 1 inch to be used shall begin 1 inch away from the ring which is nearest to the heart of the block.

7. Size of Blocks

The blocks may vary in length from 5 to 10 inches, the maximum length not to exceed two and one-half times the depth; they shall be 2½ to 4 inches in depth (parallel to fiber), according to condition of traffic; and they may be 2¾ to 4¼ inches in width, but in any one job all of them shall be of uniform width. A variation of $\frac{1}{16}$ inch will be allowed in the depth and ⅛ inch in the width of the blocks from that specified. In all cases the width shall be greater than the depth by at least ¼ inch.

8. Preservative Treatment

The preservative shall be either Coal Tar Paving Oil of the American Wood Preservers' Association or Grade 1 Creosote Oil of the A.R.E.A. as the Engineer directs. The method of treatment used, the amount of preservative to be contained in the blocks after treatment and the method of its determination, and the superficial condition of the blocks after treatment, shall be in accordance with the current "Standard Specification for Creosoted Wood Block Street Paving" adopted by the American Wood Preservers' Association.

9. Inspection of Blocks

All material herein specified and processes used in the manufacture of the blocks therefrom shall be subject to inspection, acceptance, or rejection at the plant of the manufacturer, which shall be equipped with all the

necessary gauges, appliances and facilities to enable the inspector to satisfy himself that the requirements of the specifications are fulfilled. The Engineer shall have the further right to inspect the blocks after delivery upon the street for the purpose of rejecting any blocks that do not meet these specifications, except that the plant inspection shall be final with respect to the kind of wood, rings per inch, preservative and treatment.

10. Method of Laying Blocks

The contractor shall furnish and lay the wood blocks under the direct supervision of the manufacturer and shall arrange for such supervision. Blocks shall be laid either by the Bituminous Paint Coat Method or by the Mortar Bed Method or by the Bituminous Mastic Cushion Method of the American Wood Preservers' Association as the Engineer directs and as set forth hereinbelow.

(a) Bituminous Paint Coat Method.—Upon the concrete foundation, which shall first be thoroughly cleaned and dried, shall be spread a thin, hot, uniform coating of coal tar pitch, special pitch filler, or asphalt, conforming to the current standard specifications for such materials and methods of their test adopted by the American Wood Preservers' Association. The bitumen shall be heated to a temperature of not less than 250 deg. Fahr., and not more than 300 deg. Fahr., and mopped or flushed over the concrete, while hot, to a uniform thickness of not to exceed ⅛ inch.

Upon the hardened bituminous paint coat, thus prepared, the blocks, which shall have been thoroughly dried out after treatment, shall be carefully set with the fiber of the wood vertical, in straight parallel courses with their length at right angles to line of traffic, leaving a space next to the curb 1 inch in width for an expansion joint.

The blocks shall be driven together every fourth course, to keep the rows straight and to eliminate subsequent slippage. No joint shall be more than $\frac{3}{16}$ inch in width. Nothing but whole blocks shall be used, except in starting or ending a course, and all joints shall be broken by a lap of at least 2 inches. The courses shall extend at right angles to the curb. After the blocks have been laid they shall be rolled parallel and diagonally to the curb by a tandem roller weighing between 2½ and 5 tons until the surface becomes smooth and is brought truly to the grade and contour of the finished pavement.

(b) Mortar Bed Method.—Upon the concrete foundation, which shall first be cleaned and thoroughly wetted and which shall be finished to within ½ inch of the given grade, shall be spread a layer of thoroughly mixed dry mortar, not exceeding ¾ inch in thickness and consisting of one part of Portland cement, of the character provided for in the foundation, and three parts of sand. Only sufficient water shall be added to this mixture to insure a proper setting of the cement, the intention being to produce a granular mixture which may be raked to the desired grade. The mortar shall be spread in place on the foundation immediately in advance of the laying of the blocks. The mortar bed shall be raked to the approximate grade in uniform density and struck by template to a surface parallel to the grade and contour of the finished pavement.

Upon the mortar bed thus prepared, after lightly sprinkling it with water, the blocks shall be carefully set with the fiber of the wood vertical, in straight, parallel courses with their length at right angles to the line of traffic, leaving a space next to the curb 1 inch in width for an expansion joint. The blocks shall be laid in the pavement as soon as possible after being treated. If they cannot be laid immediately, provision shall be made to prevent them from drying out by stacking in close piles and covering and sprinkling them thoroughly at intervals.

The blocks shall be laid by setting them hand-tight on the mortar bed. No joint shall be more than $\frac{3}{16}$ inch in width. They may be driven together every ten courses to keep the rows straight. Nothing but whole blocks shall be used, except in starting or ending a course, and all joints shall be broken by a lap of at least 2 inches. The courses shall extend at right angles to the curb.

After the blocks have been laid and before the mortar has set, they shall be rolled parallel and diagonally to the curb by a tandem roller weighing between 4 and 7 tons until the surface becomes smooth and is brought truly to the grade and contour of the finished pavement. All mortar that has set before the blocks are in place and rolled shall be discarded and replaced by fresh mortar.

(c) Bituminous Mastic Cushion Method.—Upon the concrete foundation which shall first be thoroughly cleaned and dried and which shall be finished to within ½ inch of the given grade, shall be spread a layer of mastic, not exceeding ¾ inch in thickness, and consisting of approximately 10 per cent suitable bituminous material, either coal tar pitch or asphaltic oil conforming to the current standard specifications for such materials and methods of their test adopted by the American Wood Preservers' Association and 90 per cent clean, dry, screened sand. The mastic shall be thoroughly mixed and spread to the approximate grade in a uniform density and struck by template to a surface parallel to the grade and contour of the finished pavement. This cushion shall be spread a day in advance of the placing of the blocks to allow the mastic to cure.

Upon the cushion thus prepared, the blocks shall be carefully set with the fiber of the wood vertical, in straight, parallel courses with their length at right angles to the line of traffic, leaving a space next to the curb 1 inch in width for an expansion joint.

The blocks shall be laid by setting them hand-tight on the cushion. No joint shall be more than $\frac{3}{16}$ inch in width. They may be driven together every ten courses to keep the rows straight. Nothing but whole blocks shall be used, except in starting or ending a course, and all joints shall be broken by a lap of at least 2 inches. The courses shall extend at right angles to the curb.

After the blocks have been laid on the cushion they shall be rolled parallel and diagonally to the curb by a tandem roller weighting between 4 and 7 tons until the surface becomes smooth and is brought truly to the grade and contour of the finished pavement.

11. Expansion Joints and Filler

Against the curb, a bituminous expansion joint one inch in width shall be formed by laying strips of that width along the curb line. After the rolling and surfacing has been completed and after removal of the strips, these spaces and the joints between the blocks shall be filled with a bituminous filler, of either coal tar pitch, special pitch filler or asphalt conforming to the current standard specifications for such materials and methods of their test adopted by the American Wood Preservers' Association.

The filler shall preferably be applied only when the temperature of the air is above 45 deg. Fahr. It shall be heated to the highest possible temperature without burning or injuring its consistency and at that temperature shall be applied by flushing over the surface of the blocks, working it into the spaces and joints by means of a hard rubber-edged squeegee. Care must be exercised to fill the joints uniformly and not leave any surplus filler on the surface. The surface of the pavement shall then be completely covered to a depth of about ½ inch with coarse, clean, sharp sand or stone screenings which shall be permitted to remain under traffic for several weeks.

The kettles in which the filler is heated shall be equipped with tested thermometers.

12. Grades of Three Per Cent or Over

When the blocks are laid on streets having grades of 3 per cent or over, it is desirable that the courses shall be spaced with open joints. This spacing may be secured by laying creosoted wood lath about $\frac{5}{16}$ inch thick between each course, or by other approved methods. The space between the blocks shall then be filled with a mastic filler, consisting of equal parts of stone screenings and bitumen, as specified above. The joints shall be filled about ⅔ full of the bituminous mastic filler above specified, care being taken to leave as little as possible on the surface of the pavement. Stone screenings shall then be spread over the surface of the pavement and permitted to work into the top of the joints under traffic. It is essential to drive the blocks together every four courses to prevent tipping and slipping of the individual blocks.

13. Adjusting Existing Structures

Manholes and catchbasin covers, valve boxes, and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the pavement surface.

14. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of said improvements to be of such quality and character as to insure the same to be free from all defects and to remain in continuous good order and condition satisfactory to the Engineer of the Railroad Company for a period of two (2) years as above set forth. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work as the Engineer of the Railroad Company may direct without additional charge or cost to the Railroad Company.

In case the paving or any part thereof is on public property where City ordinance or other ruling requires a maintenance bond, the contractor shall furnish within ten (10) days after the contract is let, a good and satisfactory bond to the amount as stated in the general contract to maintain that portion of the work on said public property as covered by this contract at the finished line and grade for a period of years as required by ordinance or ruling.

15. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the Engineer and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this specification.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 23-B

Wood Block Floors

1. General

The contractor shall furnish all labor, materials, tools and equipment, except as otherwise noted, necessary to complete entirely the wood block floors as hereinafter specified, and as shown or implied on the drawings.

2. Description

The floor shall consist of a subgrade, a concrete foundation and a wearing course of wood blocks laid over either a bituminous paint coat, a mortar bed, or a bituminous mastic cushion, applied to such foundation.

3. Subgrade and Foundation

The subgrade, if one be needed, and foundation shall be designed of sufficient strength to carry the loading to be encountered and shall be constructed in accordance with the current specification of the A.R.E.A. for Concrete for railway buildings as given in Section 4 of these specifications, except that the concrete shall be finished to a smooth even surface, with no projections of any kind, parallel to the contour of and exactly the depth below the finished floor level, corresponding to the combined depth of the block and the thickness of the paint coat, mortar bed, or mastic cushion to be used.

4. Kind of Blocks

The wood from which the blocks are to be manufactured shall be Douglas fir, Norway pine, red cypress, redwood, southern yellow pine, tamarack, western larch, or other suitable wood approved by the Engineer. Blocks

from only one kind of wood shall be used in any one contract, and they shall first be treated with a preservative as hereinafter specified except blocks of red cypress and redwood which may be used untreated and shall be well seasoned.

5. Quality of Blocks

The blocks must be sound and well manufactured, square butted, square edged, free from unsound or loose knots, holes, shakes, checks, or other defects that will impair their usefulness for floors.

In Douglas fir or southern yellow pine, the number of annual rings in the 1 inch which begins 2 inches from the pith of the block, shall not be less than six, measured radially; provided, however, that blocks containing between five and six rings in this inch shall be accepted if they contain 33⅓ per cent or more of summerwood. In case the block does not contain the pith, the 1 inch to be used shall begin 1 inch away from the ring which is nearest to the heart of the block.

6. Size of Blocks

The blocks may vary in length from 5 to 8 inches, the maximum length not to exceed three times the depth; they shall be 2½ to 4 inches in depth (parallel to fiber); and they may be 2¾ to 4¼ inches in width, but on any one floor all of them shall be of uniform width. A variation of $\frac{1}{16}$ inch will be allowed in the depth and ⅛ inch in the width of the blocks from that specified. In all cases the width shall be greater than the depth by at least ¼ inch.

7. Preservative Treatment

The preservative shall be either coal tar paving oil of the American Wood Preservers' Association or Grade 1 Creosote Oil of the A.R.E.A. as the Engineer directs. The treatment to be used, the amount of preservative to be contained in the blocks after treatment and method of its determination, and the superficial condition of the blocks after treatment, shall be in accordance with the current "Standard Specification for Interior Creosoted Wood Block Flooring" adopted by the American Wood Preservers' Association in case the blocks are to be used under dry floor conditions, and in accordance with the current "Standard Specification for Creosoted Wood Block Street Paving" adopted by the same association in case the blocks are to be used under wet floor conditions.

8. Inspection of Blocks

All material herein specified and processes used in the manufacture of blocks therefrom shall be subject to inspection, acceptance, or rejection at the plant of the manufacturer, which shall be equipped with all necessary gauges, appliances, and facilities to enable the inspector to satisfy himself that the requirements of the specification are fulfilled. The Engineer shall have the further right to inspect the blocks upon delivery for the purpose of rejecting any blocks that do not meet these specifications, except that the plant inspection shall be final with respect to the kind of wood, rings per inch, oil and treatment.

9. Method of Laying Blocks

The contractor shall furnish and lay the wood blocks under the direct supervision of the manufacturer and shall arrange for such supervision. Blocks shall be laid either by the Bituminous Paint Coat Method or by the Mortar Bed Method or by the Bituminous Mastic Cushion Method of the American Wood Preservers' Association as the Engineer directs and as set forth hereinbelow.

(a) Bituminous Paint Coat Method.—Upon the concrete foundation, which shall first be thoroughly cleaned and dried, shall be spread a thin, hot, uniform coating of coal tar pitch or asphalt, conforming to the current standard specifications for such materials and methods of their test adopted by the American Wood Preservers' Association, except that the melting point shall not be less than 130 deg. Fahr. nor more than 150 deg. Fahr. It shall be heated to a temperature of not less than 250 deg. Fahr. and not more than 300 deg. Fahr. and mopped or flushed over the concrete, while hot to a uniform thickness of not to exceed ⅛ inch.

Upon the hardened bituminous paint coat thus prepared, the blocks, which shall have been thoroughly dried out and under dry floor conditions preferably have been seasoned for a period of 30 to 60 days after treatment, or under wet floor conditions shall have been well sprinkled with water about two days before being laid, shall be carefully set with the fiber of the wood vertical, in straight parallel courses with their length at right angles to the line of traffic, leaving a space next to all walls, columns, and other obstructions, 1 inch in width for an expansion joint. Nothing but whole blocks shall be used, except in starting or ending a course, and all joints shall be broken by a lap of at least one inch.

Under dry floor conditions, the blocks shall be driven as tightly together as possible by ramming both in the direction of the courses and at right angles to them before the floor is rolled or surfaced. Under wet floor conditions, the blocks must not be driven up tightly together when wet or humid conditions are encountered.

After the blocks have been laid they shall be thoroughly tamped or rolled to a smooth level surface.

(b) Mortar Bed Method.—Upon the concrete foundation, which shall first be cleaned and thoroughly wetted and which shall be finished to within ½ inch of the given floor level, shall be spread a layer of thoroughly mixed dry mortar, not exceeding ½ inch in thickness and consisting of one part of Portland cement, of the character provided for in the foundation, and three parts of sand. Only sufficient water shall be added to this mixture to insure a proper setting of the cement, the intention being to produce a granular mixture which may be raked to the desired grade. This mortar shall be spread in place on the foundation immediately in advance of the laying of the blocks. The mortar bed shall be raked to the approximate grade in a uniform density and struck by template to a surface parallel to the grade and contour of the finished floor.

Upon the mortar bed thus prepared, after lightly sprinkling it with water, the blocks, which shall have been thoroughly dried out and under dry

floor conditions preferably have been seasoned for a period of 30 to 60 days after treatment, or under wet floor conditions shall have been well sprinkled with water about two days before being laid, shall be carefully set with the fiber of the wood vertical, in straight parallel courses with their length at right angles to the line of traffic, leaving a space next to all walls, columns, and other obstructions, 1 inch in width for an expansion joint. Nothing but whole blocks shall be used, except in starting or ending a course, and all joints shall be broken by a lap of at least one inch.

Under dry floor conditions, the blocks shall be driven as tightly together as possible by ramming both in the direction of the courses and at right angles to them before the floor is rolled or surfaced. Under wet floor conditions the blocks must not be driven up tightly together when wet or humid conditions are encountered.

After the blocks have been laid and before the mortar has set, they shall be thoroughly tamped or rolled to a smooth level surface. All mortar that has set before the blocks are in place and rolled shall be discarded and replaced by fresh mortar.

(c) Bituminous Mastic Cushion Method.—Upon the concrete foundation, which shall first be thoroughly cleaned and dried and which shall be finished to within ½ inch of the given floor level, shall be spread a layer mastic, not exceeding ¾ inch in thickness consisting of approximately 10 per cent suitable bituminous material, either coal tar pitch or asphaltic oil, conforming to the current standard specifications for such materials and methods of their test adopted by the American Wood Preservers' Association, and 90 per cent clean, dry, screened sand. The mastic shall be thoroughly mixed and spread to the approximate grade in a uniform density and struck by template to a surface parallel to the grade and contour of the finished floor. This cushion shall be spread a day ahead of the placing of the blocks to allow the mastic to cure.

Upon the cushion thus prepared, the blocks, which shall have been thoroughly dried out and under dry floor conditions preferably have been seasoned for a period of 30 to 60 days after treatment, or under wet floor conditions shall have been well sprinkled with water about two days before being laid, shall be carefully set with the fiber of the wood vertical, in straight parallel courses with their length at right angles to the line of traffic, leaving a space next to all walls, columns, and other obstructions, 1 inch in width for an expansion joint. Nothing but whole blocks shall be used, except in starting or ending a course, and all joints shall be broken by a lap of at least one inch.

Under dry floor conditions, the blocks shall be driven as tightly together as possible by ramming both in the direction of the courses and at right angles to them before the floor is rolled or surfaced. Under wet floor conditions the blocks must not be driven up tightly together when wet or humid conditions are encountered.

After the blocks have been laid they shall be thoroughly tamped or rolled to a smooth level surface.

10. Expansion Joints and Filler

Against the walls on all sides of the floor, as well as around all columns and other obstructions, a bituminous expansion joint 1 inch in width shall

be formed by laying strips of that width against and round them. After tamping or rolling has been completed and after removal of the strips, these spaces and the joints between the blocks shall be filled to within an inch of the top with a bituminous filler, of either coal tar pitch or asphalt conforming to the current standard specifications for such materials and methods of their test adopted by the American Wood Preservers' Association.

The filler shall be heated to the highest possible temperature without burning or injuring its consistency, and at that temperature shall be applied by flushing over the surface of the floor, working it into the spaces and joints by means of a rubber edged squeegee. Care must be exercised to fill the joints uniformly and not to leave any surplus filler on the surface. The surface of the floor shall then be covered with sharp, fine sand, which shall be permitted to remain under traffic for a week or ten days. The light film of bituminous material on the surface of the blocks will wear off readily under traffic.

The kettles in which the filler is heated shall be equipped with tested thermometers.

11. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of said interior flooring to be of such quality and character as to insure the same to be free from all defects and to remain in continuous good order and condition satisfactory to the Engineer of the Railroad Company for a period of two (2) years as above set forth. The guarantee shall include all repairs to be made, or, if necessary, the entire reconstruction of the work as the Engineer of the Railroad Company may direct without additional charge or cost to the Railroad Company.

12. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the Engineer and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this specification.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 25-A

Asphalt Block Pavements

1. General

The contractor shall furnish all labor, material, tools and equipment except as otherwise noted, necessary to entirely complete the asphalt block paving as hereinafter specified, and as shown or implied on the drawings.

2. **Description**

The pavement shall consist of a subgrade, a concrete foundation and asphalt blocks laid thereon in a mortar bed.

3. **Grading, Subgrade and Foundations**

Grading, subgrade and foundation shall be constructed in accordance with the current specifications of the A.R.E.A. for Concrete Pavement, except that joints shall be omitted, and the concrete finished to a smooth even surface, exactly the depth below the finished pavement corresponding to the depth of the block used.

4. **Curb and Gutter**

The curb and gutter shall be built in the location and to the elevation, sizes and cross-section shown on drawings.

All cement and concrete materials and workmanship shall comply with the specifications for Concrete as given in Section 4 of these specifications.

5. **Blocks**

Asphalt blocks shall be of ..... make compressed to at least 4000 lb. per square inch at 225 deg. Fahr. Blocks shall be 5 inches in width, 12 inches in length unless the depth required is less than 2 inches, in which case they shall be 4 inches in width by 8 inches in length. The depth shall be shown on the plans. A variation either way from these dimensions of ¼ inch in length or ⅛ inch in width or depth will be sufficient cause for rejection of any block.

6. **Mortar Bed**

There shall be placed upon the surface of the foundation, which is to be cleaned and wetted, a bed of cement mortar ½ inch in thickness. This mortar bed shall be composed of Portland cement and clean, sharp sand, which shall be free from pebbles over ¼ inch in diameter. The mortar shall be made in proportions of one part cement to four parts of sand. The ingredients shall be mixed with good clean water to such consistency that it can easily be spread upon the surface and struck with template to a smooth and even face. It must not, however, be so thin as to allow the blocks to sink into the mortar when placed thereon. This mortar shall be struck to a true surface exactly parallel to the top of the finished pavement and the required depth of the block below it, in the following manner.

On the surface of the foundation shall be set strips of wood 4 inches wide by ¼ inch thick, and of a convenient length or strips of metal 4 inches wide by ⅛ inch or $\frac{3}{16}$ inch thick, of convenient length may be used. These strips shall be carefully set from curb to curb to the exact crown of the finished work, and embedded throughout their length in mortar, so that the top surface of the strips shall be the depth of the block below the grade of the finished surface, and not less on the average than ½ inch above the concrete. An iron-shod straight-edge or "striker" shall be drawn on the two sets of strips, set as above described, to strike the mortar bed to a true and even surface. Special care must be taken to produce a bed of uniform

density. The mortar bed shall be showered with fresh mortar and struck off as many times as is necessary to produce a uniformly dense bed, free from depressions. As soon as a bed has been struck one set of strips shall be taken up, and the trench carefully filled with mortar.

7. Laying Blocks

Upon the mortar bed prepared as described above, the blocks shall be immediately laid with close joints and uniform top surface. The blocks shall be laid by the pavers standing upon the blocks already laid, and not upon the bed of mortar, and shall be laid at right angles with the lines of the curb, with such crown as is shown on the plans, and in such a manner that all longitudinal joints shall be broken by a lap of approximately four inches. The blocks shall be laid so as to make the lateral joints as tight as possible, consistent with keeping a good alignment of the cross-wise course, and where possible, the longitudinal joints shall be immediately closed by pressing each course in the direction of its length with a lever.

8. Joints

Asphalt Joints.—As soon as practicable after laying the blocks, and making necessary corrections, the surface of the pavement shall be swept clean and hot asphalt applied with squeegee or other approved machine over the entire area. This asphalt shall have a melting point, ring and ball, of not less than 80 deg. Fahr. and in all other respects shall comply with the requirements for asphaltic cement except for penetration. It shall be heated to a sufficient temperature without burning, to run freely into the joints, and leave as little as possible on the surface of the blocks. A thin layer of clean, coarse sand or stone screenings passing a ¼ inch screen shall immediately be spread over the pavement surface and left until the joints are entirely filled with sand and asphalt worked in by the action of traffic.

Sand Joints.—After the blocks have been laid the pavement shall be covered with fine, clean, dry sand which shall be thoroughly swept into the joints. The excess sand shall then be removed from the surface of the pavement and a squeegee coat of bitumen shall be applied in such manner as to insure the sealing of the joints and the coating of the surface.

Grout Joints.—After the mortar bed has taken its initial set, the joints shall be filled with a thin grout mixed in the proportions of 1 part cement to 1½ parts of fine sand.

The sand joint is the method most generally used for 2 inch and 2½ inch blocks. For the 1¼ inch block the joint should be either grouted or filled with asphalt. It is recommended that the asphalt filled joint be used for all sizes of blocks when used for pavement and for installations exposed to the weather.

9. Surfacing

The surfaces shall remain at a constant level, all edges of the blocks shall be flush with other edges at the same joint, and if they are not laid to meet this condition, the finished surface shall be ground by machines

similar to those used for grinding terrazzo, the grinding medium being a No. 20 or 30 carborundum block. This grinding will be done as an alternative to lifting and re-laying and the decision as to which method to use will be at the direction of the Engineer.

10. Adjusting Existing Structures

Manholes and catchbasin covers, valve boxes, and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the pavement surface.

11. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of the work, to be of such quality and character as to insure the same to be free from all defects, and to remain in continuous good order and condition satisfactory to the Engineer for a period of one year. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work, as the Engineer may direct, without additional charge or cost to the Railroad Company.

12. General Conditions

All material entering into this work, and all methods used by the contractor, shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this specification.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 25-B

Asphalt Block Floors

1. General

The contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, necessary to entirely complete the asphalt block flooring as hereinafter specified, and as shown or implied on the drawings.

2. Description

The floor shall consist of a subgrade, a concrete foundation and asphalt blocks laid thereon in a mortar bed.

3. Subgrade and Foundation

The subgrade, if one be needed, and the foundation shall be designed of sufficient strength to carry the loading to be encountered, and shall be constructed in accordance with the current specifications of the A.R.E.A. for Concrete for railway buildings as given in Section 4 of these specifications,

except that the concrete shall be finished to a smooth even surface, with no projections of any kind, parallel to the contour of and exactly the depth below the finished floor level, corresponding to the combined depth of the block and the thickness of the mortar bed used.

4. Blocks

Asphalt blocks shall be of ..... make compressed to at least 4000 lb. per square inch at 225 deg. Fahr. Blocks shall be 5 inches in width, 12 inches in length unless the depth required is less than 2 inches, in which case they shall be 4 inches in width by 8 inches in length. The depth shall be shown on the plans. A variation either way from these dimensions of ¼ inch in length or ⅛ inch in width or depth will be sufficient cause for rejection of any block.

5. Mortar Bed

There shall be placed upon the surface of the foundation, which is to be cleaned and wetted, a bed of cement mortar ½ inch in thickness. This mortar bed shall be composed of Portland cement and clean, sharp sand, which shall be free from pebbles over ¼ inch in diameter. The mortar shall be made in proportions of one part cement to four parts of sand. The ingredients shall be mixed with good clean water to such consistency that it can easily be spread upon the surface and struck with template to a smooth and even face. It must not, however, be so thin as to allow the blocks to sink into the mortar when placed thereon. This mortar shall be struck to a true surface exactly parallel to the top of the finished floor and the required depth of the block below it, in the following manner.

On the surface of the foundation shall be set strips of wood 4 inches wide by ¼ inch thick, and of a convenient length, or strips of metal 4 inches wide by ⅛ inch or $\frac{3}{16}$ inch thick, of convenient length may be used. These strips shall be carefully set from curb to curb to the exact crown of the finished work, and embedded throughout their length in mortar, so that the top surface of the strips shall be the depth of the blocks below the grade of the finished surface, and not less on the average than ½ inch above the concrete. An iron-shod straight-edge or "striker" shall be drawn on the two sets of strips, set as above described, to strike the mortar bed to a true and even surface. Special care must be taken to produce a bed of uniform density. The mortar bed shall be showered with fresh mortar and struck off as many times as is necessary to produce a uniformly dense bed, free from depressions. As soon as a bed has been struck one set of strips shall be taken up, and the trench carefully filled with mortar.

6. Laying Blocks

Upon the mortar bed prepared as described above, the blocks shall be immediately laid with close joints and uniform top surface. The blocks shall be laid by the workmen standing upon the blocks already laid, and not upon the bed of mortar, and shall be laid at right angles with the longitudinal axis of building with such crown as is shown on the plans, and in such a manner that all longitudinal joints shall be broken by a lap of approximately four inches. The blocks shall be laid so as to make the lateral joints as

tight as possible, consistent with keeping a good alignment of the crosswise course, and where possible, the longitudinal joints shall be immediately closed by pressing each course in the direction of its length with a lever.

7. Joints

Asphalt Joints.—As soon as practicable after laying the blocks, and making necessary corrections, the surface of the floor shall be swept clean and hot asphalt applied with squeegee or other approved machine over the entire area. This asphalt shall have a melting point, ring and ball, of not less than 80 deg. Fahr. and in all other respects shall comply with the requirements for asphaltic cement except for penetration. It shall be heated to a sufficient temperature without burning, to run freely into the joints, and leave as little as possible on the surface of the blocks. A thin layer of clean, coarse sand or stone screenings passing a ¼ inch screen shall immediately be spread over the floor surface and left until the joints are entirely filled with sand and asphalt worked in by the action of traffic.

Sand Joints.—After the blocks have been laid the floor shall be covered with fine, clean, dry sand which shall be thoroughly swept into the joints. The excess sand shall then be removed from the surface of the floor and a squeegee coat of bitumen shall be applied in such manner as to insure the sealing of the joints and the coating of the surface.

Grout Joints.—After the mortar bed has taken its initial set, the joints shall be filled with a thin grout mixed in the proportions of 1 part cement to 1½ parts of fine sand.

The sand joint is the method most generally used for 2 inch and 2½ inch blocks. For the 1¼ inch block the joint should be either grouted or filled with asphalt. It is recommended that the asphalt filled joint be used for all sizes of blocks when used for pavement and for installations exposed to the weather.

8. Surfacing

The surface shall remain at a constant level, all edges of the blocks shall be flush with other edges at the same joint, and if they are not laid to meet this condition, the finished surface shall be ground by machines similar to those used for grinding terrazzo, the grinding medium being a No. 20 or 30 carborundum block. This grinding will be done as an alternative to lifting and re-laying and the decision as to which method to use will be at the direction of the Engineer.

9. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of the work, to be of such quality and character as to insure the same to be free from all defects, and to remain in continuous good order and condition satisfactory to the Engineer for a period of one year. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work, as the Engineer may direct, without additional charge or cost to the Railroad Company.

10. **General Conditions**

All material entering into this work, and all methods used by the contractor, shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this specification.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 26-A

Macadam Pavements

1. **General**

The contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, necessary to entirely complete the macadam paving as hereinafter specified and as shown or implied on the drawings.

2. **Description**

The pavement shall consist of a subgrade and three courses of broken stone with proper binder; viz., a foundation course 6 inches in depth, a second course 4 inches in depth, and a top surface screenings course ⅜ inch in depth with curb or combined curb and gutter for pavement as shown on drawings.

3. **Grading and Subgrade**

Grading and subgrade shall be constructed in accordance with the current specification of the A.R.E.A. for Concrete Pavements.

4. **Curb and Gutter**

The curb or the curb and gutter shall be built in the location and to the elevation, sizes and cross-section shown on drawings.

All cement and concrete materials and workmanship shall comply with the specifications for Concrete as given in Section No. 4 of these specifications. Not more than seven (7) gallons of water shall be used to each sack of cement.

5. **Stone for Pavement**

Stone and screenings shall be of hard and compact texture and of uniform grade. The fragments shall approach the shape of a cube as nearly as possible and have rough surfaces such as are obtained by fracture. Waterworn pebbles will not be accepted. Disintegrated and rotten stone from the surface of quarry will not be accepted. All stone shall be thoroughly clean before crushing and must be well screened and free from injurious matter of every nature. The contractor shall state in his proposal at what quarries he is to secure stone.

6. Roller

The roller shall be self-propelled and weigh not less than ten tons.

7. Foundation Course

Upon the subgrade prepared in the manner above described shall be spread a layer of broken stone which, when thoroughly compacted, shall not be less than 6 inches in thickness. The stone shall be broken so as to measure not more than 2 inches and not less than 1 inch in any dimension. After this stone is spread, screenings, which shall pass through a ½ inch mesh, shall be swept into the interstices with rattan or steel brooms. In no case shall the screenings be dumped onto the course but shall be spread with a shovel.

The surface shall then be rolled and screenings spread until the interstices are apparently filled. Then the surface shall be rolled and sprinkled and screenings spread until all the interstices are filled and the stones do not creep or weave in front of the roller. The roller shall begin at the outer edge of the pavement, run parallel to the center line of the roadway and work towards the center. When the center is reached the roller shall begin at the other edge and again work towards the center. When there is a shoulder care shall be taken not to crush same by overlapping the stone with the roller. If any depressions occur, they shall be filled with stones of the specified size (not screenings) and rolled. No surplus screenings shall remain on the surface.

8. Second Course

On the foundation course prepared in the above described manner shall then be spread a layer of broken stone which, when thoroughly compacted, shall be at least 4 inches in thickness. The stone shall be broken so as to measure not more than one inch nor less than ½ inch in any dimension. The surface shall be rolled dry. Screenings shall then be spread and swept into the interstices as described for the foundation course excepting that no water shall be used. The screenings shall pass through a ½ inch mesh. The rolling and spreading shall continue until all interstices are filled and the stones do not crawl or weave in front of the roller. The roller shall work in the manner described for the foundation course excepting that where there is a shoulder the rear wheel of the roller should be half on the shoulder and half on the stone when starting at the outer edge. If any depressions occur, they shall be filled with stone of the specified size (not with screenings) and the surface rolled.

9. Top Surface Screenings

On the surface of the second course prepared in the above described manner shall be spread a layer of screenings which shall entirely cover the surface with a coat approximately ⅜ inch thick when thoroughly compacted. The screenings shall pass through a ½ inch mesh. The screenings shall be sprinkled until thoroughly wet and then rolled, the roller keeping immediately behind the sprinkler. The rolling should continue until a grout is formed and a wave of grout continually forms in front of the roller. Screenings should not be dumped on the second course but should

be placed at one side and spread over the surface with shovels. After the rolling is finished, the pavement shall be closed to traffic until the surface is thoroughly dry.

10. Adjusting Existing Structures

Manhole and catchbasin covers, valve boxes and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the surface of the pavement.

11. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of said improvements, to be of such quality and character as to insure the same to be free from all defects, and to remain in continuous good order and condition satisfactory to the Engineer of the Railroad Company for a period of two years as above set forth. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work, as the Engineer of the Railroad Company may direct, without additional charge or cost to the Railroad Company.

In case the paving or any part thereof is on public property where City ordinance or other ruling requires a maintenance bond, the contractor shall furnish within 10 days after the contract is let, a good and satisfactory bond to the amount as stated in the general contract to maintain that portion of the work on said public property as covered by this contract at the finished line and grade for a period of years as required by ordinance or ruling.

12. General Conditions

All materials entering into the work, and all methods used by the contractor, shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section 1 of these specifications shall be considered to apply with equal force to this specification.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Committee VI—Buildings

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 26-B

Asphalt Macadam Pavements

1. General

The contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, necessary to entirely complete the asphalt macadam paving as hereinafter specified and as shown or implied on the drawings.

2. **Description**

The pavement shall consist of a subgrade and two courses of broken stone with proper binder, viz., a base course 6 inches in depth and a wearing course 4 inches in depth with curb or combined curb and gutter as shown on drawings. The wearing course shall have asphalt cement binder.

3. **Grading and Subgrade**

Grading and subgrade shall be constructed in accordance with the current specification of the A.R.E.A. for Concrete Pavements.

4. **Curb and Gutter**

The curb or the curb and gutter shall be built in the location and to the elevation, sizes and cross-section shown on drawings.

All cement and concrete materials and workmanship shall comply with the specifications for Concrete as given in Section No. 4 of these specifications. Not more than seven (7) gallons of water shall be used to each sack of cement.

5. **Stone for Pavement**

Broken stone and screenings shall be of hard and compact texture and of uniform grade. The fragments shall approach the shape of a cube as nearly as possible and have rough surfaces such as are obtained by fracture. Waterworn pebbles will not be accepted. Disintegrated and rotten stone from the surface of quarry will not be accepted. All stone shall be thoroughly clean before crushing and must be well screened and free from injurious matter of every nature. The contractor shall state in his proposal at what quarries he is to secure stone.

6. **Asphalt Cement Binder**

The asphaltic cement shall meet the requirements of the American Society for Testing Materials for asphalt cement of 100 to 120 penetration, Specification D-103-24T and current revisions thereof.

7. **Roller**

The roller shall be self-propelled and weigh not less than ten tons.

8. **Foundation Course**

Upon the subgrade prepared in the manner above described shall be spread a layer of broken stone which, when thoroughly compacted, shall not be less than 6 inches in thickness. The stone shall be broken so as to measure not more than 2 inches and not less than 1 inch in any dimension. After this stone is spread, screenings, which shall pass through a ½ inch mesh, shall be swept into the interstices with rattan or steel brooms. In no case shall the screenings be dumped onto the course but shall be spread with a shovel.

The surface shall then be rolled and screenings spread until the interstices are apparently filled. Then the surface shall be rolled and sprinkled and screenings spread until all the interstices are filled and the stones do not creep or weave in front of the roller. The roller shall begin at the

outer edge of the pavement, run parallel to the center line of the roadway and work towards the center. When the center is reached the roller shall begin at the other edge and again work towards the center. When there is a shoulder care shall be taken not to crush same by overlapping the stone with the roller. If any depressions occur, they shall be filled with stones of the specified size (not screenings) and rolled. No surplus screenings shall remain on the surface.

9. Second Course

On the foundation course prepared in the above described manner shall then be spread a layer of broken stone which, when thoroughly compacted, shall be at least 4 inches in thickness. The stone shall be broken so as to measure not more than one inch nor less than ½ inch in any dimension. The surface shall be rolled dry. To each square yard of this layer shall be applied not less than 2¼ to 2½ gallons of asphalt cement binder in such manner that the stone is thoroughly and uniformly coated. The asphaltic cement shall be applied at a temperature of not less than 300 or more than 350 deg. Fahr. Screenings shall then be spread and swept into the interstices as described for the foundation course excepting that no water shall be used. The screenings shall pass through a ½ inch mesh. The rolling and spreading shall continue until all interstices are filled and the stones do not crawl or weave in front of the roller. The roller shall work in the manner described for the foundation course excepting that where there is a shoulder the rear wheel of the roller should be half on the shoulder and half on the stone when starting at the outer edge. If any depressions occur, they shall be filled with stone of the specified size (not with screenings) and the surface rolled.

10. Top Surface

The surface of the second course shall then be swept and any excess of stone removed. To each square yard of surface shall then be applied not less than ½ to ¾ gallon of asphaltic cement, and the surface again dressed with ⅛ to ⅜ inch stone chips or hard gravel, free from dust. Rolling with a steam roller shall then continue until the surface is true, uniform and compact.

The screenings shall pass through a ½ inch mesh.

The asphaltic cement shall be applied at a temperature of not less than 300 or more than 350 deg. Fahr.

11. Adjusting Existing Structures

Manhole and catchbasin covers, valve boxes and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the surface of the pavement.

12. Guaranty

It is hereby understood and agreed that the contractor shall guarantee the material furnished and used and the workmanship employed in the construction of said improvements, to be of such quality and character as

to insure the same to be free from all defects, and to remain in continuous good order and condition satisfactory to the Engineer of the Railroad Company for a period of two years as above set forth. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work, as the Engineer of the Railroad Company may direct, without additional charge or cost to the Railroad Company.

In case the paving or any part thereof is on public property where City ordinance or other ruling requires a maintenance bond, the contractor shall furnish within 10 days after the contract is let, a good and satisfactory bond to the amount as stated in the general contract to maintain that portion of the work on said public property as covered by this contract at the finished line and grade for a period of years as required by ordinance or ruling.

13. General Conditions

All materials entering into the work, and all methods used by the contractor, shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted. The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this specification.

MONOGRAPHS

A

FREIGHT TRAIN CURVE-RESISTANCE ON A ONE-DEGREE CURVE AND A THREE-DEGREE CURVE*

By Edward C. Schmidt,

Professor of Railway Engineering, University of Illinois

I. INTRODUCTION

When a train runs on curved track there is a certain excess of resistance over that encountered when it runs on straight track. This excess is termed curve resistance, and it is usually expressed in pounds per ton of train weight per degree of curve. Its magnitude is generally assumed to lie between the limits of 0.3 of a pound and 1.0 pound per ton per degree. Very frequently its general average value is assumed to be one-half pound per ton per degree.

There are few published records of direct determinations of curve resistance for American cars and track; and the scarcity of experimental data has seemed to warrant the publication of the results here presented. The practice of compensating curves on grades has, when successful, produced indirect evidence concerning the magnitude of curve resistance; and the Manual of the American Railway Engineering Association gives rules for compensating curves, which imply a very detailed and definite knowledge of curve resistance. There remains nevertheless great divergence of opinion as to its amount.

This paper presents the results of tests made with five freight trains on a one-degree curve and a three-degree curve. The final results are given in Table 5 on page 19 and in Fig. 13 on page 21. The results are discussed in Section V and the discussion is summarized on page 27.

The test results relate exclusively to the resistance of the cars composing the train—the curve resistance of the locomotive is not discussed. The results apply only to freight trains with four-wheeled trucks; although the resistance of four-wheeled truck passenger cars of similar wheel-base is probably not very different.

Throughout this report the terms "resistance" and "net resistance" mean the number of pounds of tractive force required for each ton of train weight in order to keep the train moving on straight and level track, at uniform speed, in still air. The term "resistance on the curve" means the number of pounds of tractive force required for each ton of train weight in order to keep the train moving on a level curve, at uniform speed, in still air. "Curve resistance" is the difference between resistance on the curve and net resistance, divided by the degree of the curve; and it is expressed therefore in pounds per ton per degree of curve.

The tests were undertaken primarily to determine the relative merits of three designs of freight car trucks, that is, to determine the effects

*This paper is an abridgment of Bulletin 167, of the Engineering Experiment Station of the University of Illinois.

of truck design upon train resistance on straight track and on curves. In arranging the tests it was clear from the outset that they would provide an exceptional opportunity to measure curve resistance and they were so planned as to make this their secondary purpose. To this end provision was made to acquire and record such data as super-elevation, rail wear, variation in gauge, and the like, which were not of first importance for the primary purpose.

This paper is an abridgment of Bulletin 167 of the Engineering Experiment Station of the University of Illinois, and is here published by the permission of M. S. Ketchum, Director of the Station. The bulletin presents additional details concerning the test track and the trains, and a somewhat fuller discussion of the test conditions.

II. THE TRACK AND THE TRAINS

1. **The Test Track.**—Both the primary and the secondary purpose of the tests required that the trains tested be of at least a length comparable with that of short trains in service; and considerations of accuracy in the resistance determination demanded that its average value be measured over a distance of about 1000 feet, with the entire train running on the curve. These requirements implied that the curves ought to be about 1800 feet long; which, of course, hampered the choice of the test track, and practically barred from consideration curves of great curvature. The track finally chosen for the tests consists of a three-degree left curve 1733 feet long, followed by 296 feet of tangent which was followed by a one-degree curve 3137 feet long; this one-degree curve was followed in turn by 3341 feet of straight track. The test track is represented in Fig. 1.

This track was especially surveyed for the purposes of this work, immediately preceding the tests. Elevations on both rails were measured at stations 100 feet apart; and the curvature on each of the curves was determined for each 100-foot interval. On the one-degree curve the track gauge was measured every 200 feet; and on the three-degree curve, every 100 feet. On the one-degree curve the gauge varied from 56.4″ to 57.1″ and its average was 56.7″; on the three-degree curve it varied between 56.5″ and 57.2″, and averaged 56.8″.

At the time the tests were made the test track was in fair condition. The roadbed was about ten years old; it was ballasted with gravel, had a 12-foot crown, and carried a single track. The ties were of untreated oak, about 7″x9″x8′, and were spaced about 21″ center to center. The rails were Illinois Steel Company's section No. 7010, weighing 70 lb. per yard; they were laid with the joints staggered and joined by 22″ angle splices, secured by four bolts at each joint. On the three-degree curve rail braces were applied, about 20 feet apart, on both rails.

On the one-degree curve the contours of the rail heads were determined on every eighth rail; and on the three-degree curve, on every fourth rail. These contours are shown in Fig. 14, where the worn contours lie within

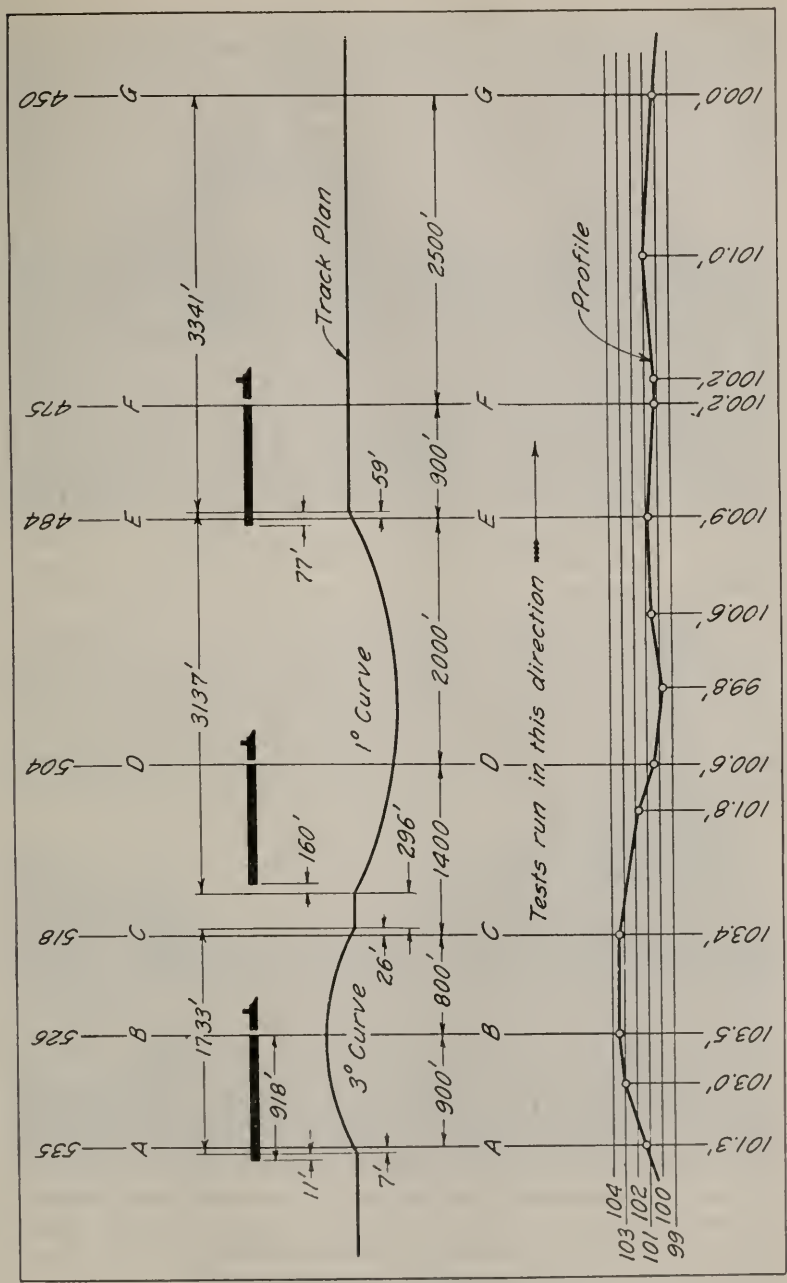


Fig. 1. Diagram of the Test Track

the blackened areas of the rail diagrams. The diagram outlines represent the contour of the unworn rail. The sections as printed are of full size.

All the calculations of resistance on the three-degree curve included in this bulletin relate to the period during which the head end of the train (the rear end of the dynamometer car) passed from point B to point C (Fig. 1), a distance of 800 feet; on the one-degree curve the results relate to the period while the head end passed from D to E, a distance of 2000 feet; and on the tangent the results relate to the interval from F to G—2500 feet. With the head end at B, 11 feet of the rear end of the train were on a tangent and the remainder of the train was on the three-degree curve; with the head end at D, the entire train was on the one-degree curve; when the head end was at F, 77 feet of the rear of the train were still on the one-degree curve. This overhang of the train when it was about to enter the test stretches on the three-degree curve and on the tangent arose from failure accurately to forecast the train length when stations B and F were located, and its slight effect has been ignored in the calculations.

While the trains passed from B to C on the three-degree curve they were subjected to the effects of an average super-elevation of 3.71 inches and of an average track curvature of 2°—58½′, which, in deriving the values of curve resistance, has been taken as equivalent to 3.0 degrees. While the trains passed from D to E on the one-degree curve they were subjected to the effects of an average super-elevation of 0.89 inches and of an average track curvature of 1.0 degree.

2. **The Trains.**—Tests were made with five trains whose principal characteristics are indicated in Table 1. The five trains differ solely in the construction of the trucks and in the presence or absence of load on the cars. They were all composed of 20 identical flat-car bodies arranged in the same order in all trains. Wheels, axles, and journal brasses were identical in all five trains; and in trains 1, 2 and 3 the load was the same and

Table 1—Train Data

Train Number	Cars, Loaded or Empty	Type of Truck	Number of Cars in the Train*	Length of the Train behind the Test Car — Feet	Train Weight — Tons	Average Weight Per Car — Tons	Average Side-bearing Clearance — Inches
1	Loaded	A	21	918	1019.7	48.6	0.22
2	Loaded	C	21	918	1019.7	48.6	.21
3	Loaded	B	21	918	1019.7	48.6	.21
4	Empty	C	21	918	316.3	15.1	.28
5	Empty	B	21	918	316.3	15.1	.28

*The values given in columns 4 to 8 include the caboose; but they exclude the dynamometer car.

was composed of the identical material on each car. The car weights for all trains were determined by weighing the cars on track scales. Since the dynamometer car was continually run with its measuring drawbar toward the rear of the train, its own resistance did not register on the car records and its weight is therefore excluded from the train weight.

Fig. 2. The Test Car and the Test Crew

Fig. 3. One of the Loaded Trains on the Three-Degree Curve

The tests were begun with train No. 2 which was equipped with trucks of type C. Truck B, which was used on trains 3 and 5, is merely truck C with certain parts removed, and this removal was effected without dismounting the trucks, or disturbing the cars or their load; for train 4 truck B was re-converted into truck C by replacing these parts. Upon the completion of the tests with train No. 5, it was returned to the shops, the car bodies were lifted by a crane and the trucks removed—first removing the wheels and axles and journal brasses. Trucks of type A were then placed in position under the car and the wheels and axles and brasses were placed in the new trucks, care being taken to restore each axle to its original position, and each brass to its original journal. There was then replaced on each car the identical load it had borne in trains 2 and 3, and the cars were re-assembled in their original order. The train thus constituted is here designated as train No. 1. These unusual arrangements to attain similarity among the trains were regarded as necessary to the primary purpose of the tests—the comparison of truck performance. While they were not essential to the determination of curve resistance, they have not made the curve resistance results less general in their application.

All three types of trucks were of cast steel construction, and they are representative of trucks encountered in service. Scores of thousands of trucks of types A and B are in freight service on American and Canadian railroads, and the special features in the construction of truck C do not make its action dissimilar to that of trucks in common use.

All cars were steel-underframe flat cars built from the same designs. Their principal dimensions were:

Height from rail to top of deck	4′ 0⅝″
Length over striking plates	41′ 6 ″
Length between pulling faces of coupler knuckles	43′ 6 ″
Center to center of trucks	30′ 0 ″
Truck wheel-base	5′ 6 ″
Wheel diameter	33 ″
Size of journals	5″ x 9 ″
Average height of center of gravity of empty cars above the rail	29.3 ″
Average height of center of gravity of loaded cars above the rail	53.5 ″
Average weight of empty cars	30,075 lb.
Average weight of car body	16,375 lb.
Average weight of each truck, complete with wheels and axles (same for all three types)	6,850 lb.

The cars and all trucks were comparatively new; and the brasses, journals, wheel treads, and wheel flanges were in general in excellent condition. Upon the completion of the tests all truck parts were examined. Tested by the Master Car Builders' gauge, no sharp flanges were found; six flat spots, varying in length from one inch to two inches, were found on the wheel treads; on five brasses, out of the 160 in the trains, there was evidence of the brass having recently run hot; and in four brasses the babbitt was worn through. The end play between the brasses and the journal collars varied throughout the trains from ¼″ to ⅝″.

III. TEST PROCEDURE, METHODS AND CONDITIONS

3. **Test Program.**—By "test," in this connection, is meant one continuous run with any of the trains from point B to point G on the test track (Fig. 1). Tests were run at three speeds—nominally 10, 20, and 30 miles per hour. Table 2 shows the number of tests made at each of these speeds with each of the trains.

With each train it was the intention to run at each speed enough tests to define a reliable average value of train resistance at that speed—reliability being largely judged by the agreement among the resistance values. It is to be observed that notwithstanding this intention, only one test is shown for train No. 3 at 10 miles per hour. Actually, however, five tests were run with this train at this speed; but during four of them the record on the one-degree curve was incomplete and these four were rejected because it was desired that for each resistance value on the straight track there be a

TABLE 2—TEST PROGRAM

Train Number	Number of Tests Run			
	At 10 m. p. h.	At 20 m. p. h.	At 30 m. p. h.	At All Speeds
1	6	9	11	26
2	3	11	8	22
3	1	9	8	18
4	5	5	8	18
5	5	5	7	17
All Trains	20	39	42	101

strictly comparable value on each of the curves. On this account reliance is placed in this instance upon a single test; that it is not misplaced is indicated by the fact that on the three-degree curve and on the tangent, where results for five tests are available, the average resistance for all five is nearly the same as the resistance in the single test. As was just intimated, each of the tests whose results are included in the bulletin gave results not only on the tangent, but on each curve; that is, for every value of net resistance on straight track here presented there are corresponding values of resistance on the two curves, obtained from the same train within the space of a few minutes and under almost identical conditions.

4. **Immediate Purpose of the Tests.**—The immediate purpose of the tests was to determine the average gross tractive force required to move each train over the test sections. This was accomplished by means of the University of Illinois dynamometer car, which measures and graphically records drawbar pull, speed, time, wind velocity, wind direction, train line pressure, and brake cylinder pressure. This car* is shown in Fig. 2 and its recording mechanism, in Fig. 4.

*A detailed description of the car appears in "Freight Train Resistance," Bulletin 43 of the Engineering Experiment Station of the University of Illinois; and also in the Railway Age Gazette, February 19, 1909.

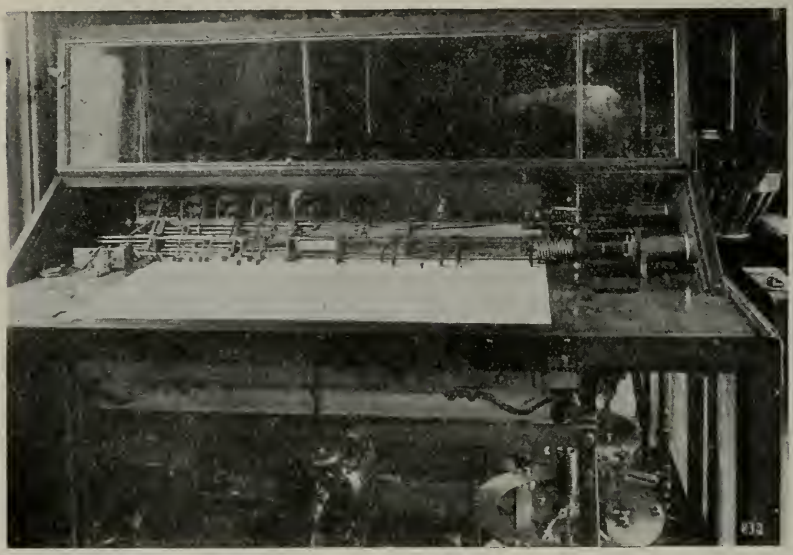


Fig. 4. The Recording Apparatus and Chart in the Dynamometer Car

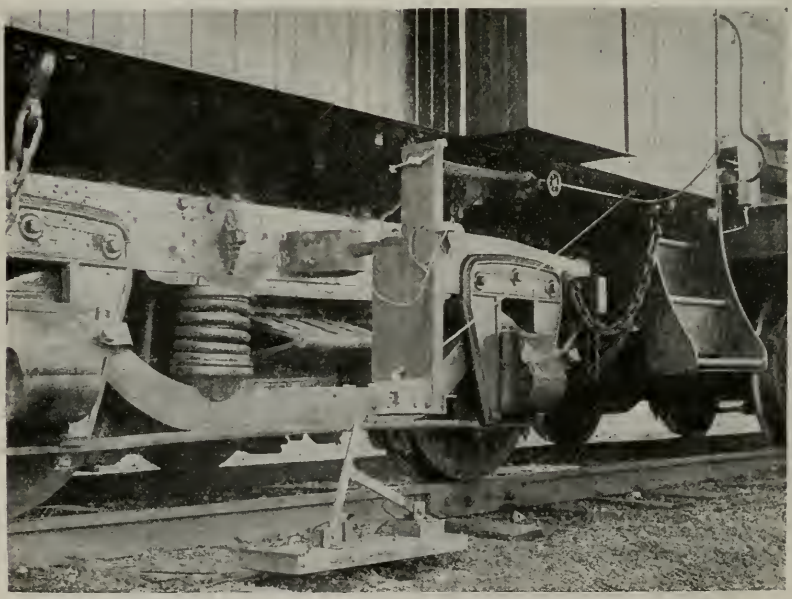


Fig. 5. The Circuit Breakers Which Operated the Pens on the Chronographs

From the test car records the average gross resistance was determined for the periods while the head of the train passed from B to C, D to E, and F to G (Fig. 1) on the three-degree curve, the one-degree curve, and the straight track, respectively. Correcting this gross resistance for grade and acceleration, we obtain the net resistance on straight track and the resistance on the curves; and the difference between these quantities is the desired curve resistance.

5. **Correction for Grade.**—The resistance due to grade was determined by use of the tonnage record and the original large-scale profile, by means of which the height of the center of gravity of the train was determined at entrance to and exit from the test sections. On the three-degree curve, for example, the height of the center of gravity of the train was calculated for the position when its head end was at B. This height was found by assuming the train to be divided into short sections, correlating these sections with the profile, and calculating for each section the height of its center of gravity above an assumed reference plane and its moment about that plane. The sum of these moments divided by the train weight gives the height of the center of gravity of the whole train. This height when the head of the train was at C was similarly calculated; and the difference between these heights defines the average grade and the resistance correction due to grade for the test stretch on the three-degree curve.

6. **Correction for Acceleration.**—The accurate determination of acceleration, important in all train resistance measurements, was of especial importance in these tests, because the test sections were short and the work to produce acceleration might, if uncontrolled, constitute a large share of the total work performed on the train in moving it over these sections; and any errors in the determination of the acceleration correction might consequently occasion large errors in net resistance. For this reason precautions were taken to maintain as nearly uniform a speed as possible over the test track and to measure with as much accuracy as possible the speeds at entrance to and exit from the test sections.

To facilitate the control of speed, a speed indicator was installed in the locomotive cab and the engineer was instructed not only to approach the test track at the predetermined speed, but to maintain until the end of the run the speed at which he passed the point B (Fig. 1). While it proved impossible precisely to conform to these instructions, his efforts did result in a much more uniform speed and a smaller acceleration correction than would otherwise have been attained.

The speed at the limits of the test sections (points B, C, D, E, F, and G in Fig. 1) was measured by means of two chronographs, one of which was located in a station building near A and the other within the test car. Two chronographs were used in order that the data might still be complete in case either of them failed to give a useful record. At each section limit—point B, for example—were placed two circuit breakers or "trips," like the one shown in the middle foreground of Fig. 5. These trips were located equidistant from B; they were accurately spaced either 60 feet or 120

feet apart, depending on the speed at which the tests were to be run, and they were connected in series in an electric circuit which extended along the track. This circuit controlled a magnet mounted on the drum chronograph in the station at A, and the magnet operated a pen which drew a line on the chronograph chart. As the test car passed each trip its upper arm was displaced by a striking board mounted on the side of the car as shown in Fig. 5, and the circuit through the trip was thereby broken until the lower arm fell into the fork at the base and reestablished it. This momentary interruption of the current caused an offset in the line drawn on the chronograph chart by the pen above referred to. The distance on the chart between these offsets represents, to some scale, the distance between trips. Another magnet-controlled pen drew on the chart a second line parallel to the one just mentioned. The magnet of this pen was actuated by a contact device in a clock, which broke contact every half second and thereby caused offsets in the time record at these intervals. By correlating the time and distance records on the chart the time elapsed in passing from trip to trip was evaluated and the average speed between trips was calculated. This average speed is the speed at the instant the head of the train passed the point B, because even though speed variation might have occurred in passing from trip to trip, the rate of variation over so short a distance must have been substantially uniform. In similar manner the speeds as the train passed the other section limits were established. Knowing these speeds, the mean accelerations in passing from B to C, D to E, and F to G were determined and the corrections for acceleration resistance were calculated therefrom.

As stated above, a second chronograph was installed within the test car. On the paper ribbon of this instrument there were also drawn a distance record and a time record by pens controlled by electro-magnets. One of these magnets was connected in series with a circuit breaker mounted on the end of the trunnion which supported the striking board hung from the side of the test car, and shown in Fig. 5. This breaker opened at the instant the board struck the track trip and it was closed again as the board was drawn back into striking position by the spring shown in the figure. This interruption of the current caused offsets in the distance record corresponding to the positions of the track trips. The time record on the car chronograph was obtained by means similar to those used on the station instrument, except that in this case the time intervals were marked by a contact-breaking chronometer which operated every one-fifth of a second. Because of its superior time record, most of the speed calculations are based upon records obtained from this chronograph in the test car, the records from the station instrument being resorted to only when the former were incomplete.

7. **Journal Temperature.**—Journal temperature has an important influence on train resistance, and the resistance of a train running at any given speed will steadily decrease until its journals reach their maximum temperature. In order therefore to ensure uniformity of operating conditions in this respect a recording thermometer was mounted on the first car

of the test trains, the bulb of the instrument being inserted in a hole drilled in the brass of one of the journals of the leading axle. The arrangement is shown in Fig. 6. In preparation for each test the train was backed up several miles from the entrance to the test track and was run sufficiently at the test speed to bring its journal temperature to a condition of equilibrium; that is, it was run until, when the train reached the point A, the temperature shown on the thermometer had reached the maximum value attainable at the speed at which the test was to be run. All tests at like speeds were run under journal temperatures very nearly alike, and all the results

Fig. 6. The Recording Thermometer Used to Measure Car Journal Temperature

presented in the bulletin show the train resistance when, for the various speeds, temperature equilibrium had been nearly or quite attained in the journals.

8. **Correction for Wind Resistance.**—Net resistance and resistance on the curve, while they necessarily include the resistance due to still air, ought properly to be corrected for the resistance due to such winds as prevailed during each test. Although from the test car records the velocity of the wind and its angle with respect to the track have been calculated for each test, no attempt has been made to apply such corrections. The failure

to do so is justified by the facts that the winds were unusually light, that their effects on flat cars are small, and that the uncertainty concerning the magnitude of wind resistance might have introduced errors almost as great as the corrections themselves. Furthermore, while the wind velocity during any one test did not always remain the same on the curves and on the straight track, it did not vary greatly, and the wind resistance errors remaining in the resistance on the curve and in the resistance on the straight track were generally substantially the same for each test; consequently, since curve resistance is the difference between these two quantities, the wind resistance errors are practically eliminated from the calculated curve resistance by the process of subtraction.

9. **Weather Conditions.**—The weather during the tests was generally fair and warm, and favorable to the development of uniform and minimum train resistance. Only 7 of the 101 tests were run during rain or on wet rails. In only two tests did the wind velocity exceed 15 miles per hour. The range in weather conditions for tests with each of the five trains is presented in Table 3.

10. **Methods of Calculation.**—The methods used in deriving the final results of the tests are, in general, the same as those described on pages 86-95 of Bulletin 43 of the Engineering Experiment Station of the University of Illinois.

Table 3—Summary of Test Conditions

Train Number	Number of Tests Made			Air Temperature		Wind Velocity	
	Total Number	Number in Dry Weather	Number in Rain or On Wet Rail	Minimum Deg. F.	Maximum Deg. F.	Minimum m. p. h.	Maximum m. p. h.
1	26	21	5	62	89	0.7	13.1
2	22	22	0	64	94	4.0	18.0
3	18	17	1	72	88	3.5	11.9
4	18	17	1	66	90	2.5	14.4
5	17	17	0	84	95	3.9	19.5
All Trains	101	94	7	62	95	0.7	19.5

IV. THE RESULTS OF THE TESTS

11. **Immediate Results.**—The immediate results of each test are three values of resistance—one for the straight track, one for the one-degree curve, and another for the three-degree curve—together with three corresponding values of speed. These values of resistance and speed, for each of the five trains, are given in Tables 6 to 10 in Appendix 1. For train No. 1, for example, Table 6 shows that during test 135, while the train passed from F to G on the straight track, its mean net resistance was 3.64 pounds per ton of train weight and its mean speed, 11.10 miles per hour. The seventh line in Table 6 shows that for all six tests made with this train at

the nominal speed of 10 miles per hour, the *average* net resistance on the straight track was 3.50 pounds per ton, and the *average* speed was 10.85 miles per hour. Table 6 provides similar individual and average values of resistance and speed for train No. 1 on each of the two curves; and Tables 7, 8, 9 and 10 give the same sort of information for the other four trains. These five tables embody all the direct results of the tests.

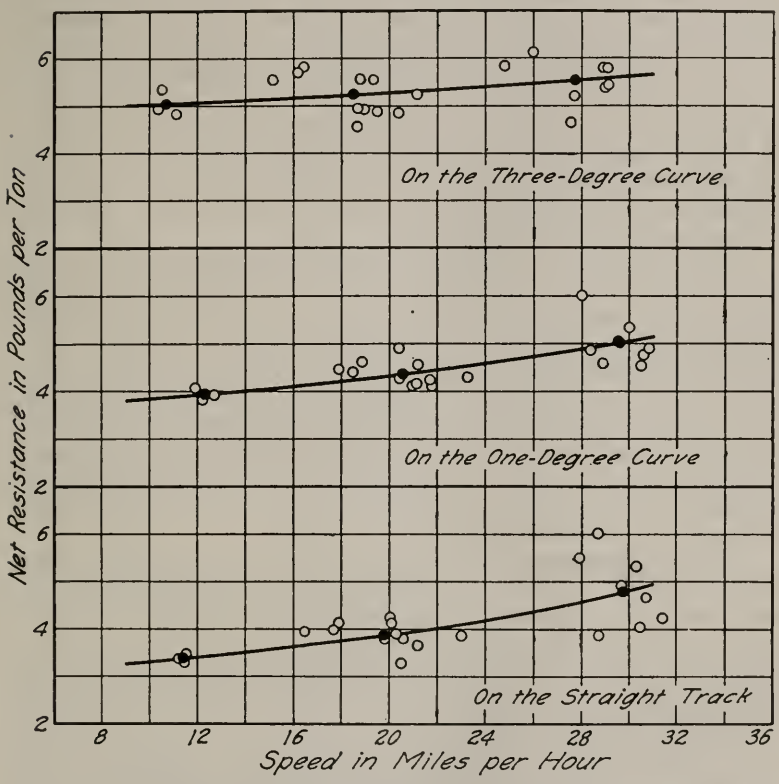


Fig. 7. Test Results for Train No. 2 on Straight Track, the One-Degree Curve, and the Three-Degree Curve

12. **Graphical Presentation of the Immediate Results.**—The next step in deriving curve resistance was to plot, as in Fig. 7, the corresponding values of resistance and speed derived from Tables 6 to 10. In Fig. 7, which is derived from Table 7 applying to train No. 2, the results of the individual tests on the straight track are plotted at the bottom of the figure. The three tests made at the nominal speed of 10 miles per hour give the three points shown as circles at the left of this diagram; the eleven tests at 20 miles per hour provide the

middle group of points; and the eight tests at 30 miles per hour give the right-hand group—all these points being defined by the co-ordinates given in the third and fourth columns of Table 7. In each group of points the black dot represents the average value of the co-ordinates of the points in that group, and it is plotted from the "average values" shown in Table 7. The curve shown in the figure has been drawn to pass through these black dots, and this curve is accepted as defining the relation between net resistance and speed for train No. 2 when running on the straight track. In similar manner, using the co-ordinates from columns 5 and 6 of Table 7, the curve in the center of Fig. 7 was drawn to define the relation between resistance and speed on the one-degree curve; while the curve at the top, plotted from the co-ordinates in the last two columns of Table 7, represents this relation on the three-degree curve. Similar diagrams showing the relation between resistance and speed on the tangent and both curves were drawn for each of the other four trains; but these diagrams are not here presented.

It may be useful to restate briefly some of the facts relating to the results of the individual tests plotted in Fig. 7. Each point represents the mean resistance for a period during which the train ran entirely on straight track, entirely on the one-degree curve, or entirely on the three-degree curve. For each point representing resistance on the straight track, there are two corresponding points representing resistance on the curves, all three resistance values being derived from measurements made within a period of a few minutes and from the same train operating under nearly identical conditions. For each point the resistance value has been corrected for resistance due to grade and acceleration, but not for the slight wind resistance which may have existed.

While the production of diagrams like Fig. 7 was designated above as the first step in deriving curve resistance from the test results, the plotting of the points representing the results of individual tests is not essential to the process; for the curves in these diagrams can be drawn—and they actually were so drawn—by limiting consideration to the three points (the black dots) which represent for each nominal speed the average relation between resistance and speed.

If consideration be limited to the *average* values of resistance and speed for train No. 2, we may plot these values as in Fig. 9, and draw the three curves there shown to define the resistance-speed relations for this train. These curves in Fig. 9 are identical with those in Fig. 7. In like manner, curves showing these relations for the four other trains have been produced and they are presented in Figs. 8, 10, 11 and 12. In all five figures the points are plotted by using the co-ordinates designated as "average values" in Tables 6 to 10 in Appendix 1. The relation between the figures, the trains, and the tables is as follows:

Fig. 8, applying to train No. 1, is derived from Table 6.
Fig. 9, applying to train No. 2, is derived from Table 7.
Fig. 10, applying to train No. 3, is derived from Table 8.
Fig. 11, applying to train No. 4, is derived from Table 9.
Fig. 12, applying to train No. 5, is derived from Table 10.

13. **Final Results—Curve Resistance.**—The resistance due to track curvature being the difference between the resistance on straight track and the resistance on the curve, the differences, at any speed, between the ordinates of the three lines drawn in Fig. 8, for example, will give the values of resistance due to track curvature at that speed for train No. 1. In this discussion, however, the values of resistance due to curvature are presented only for three speeds, which closely approach the general average test speeds, namely 10, 20 and 30 miles per hour; because, since the lines in the figure are defined by only three points, their validity is questionable except in the immediate vicinity of those points.

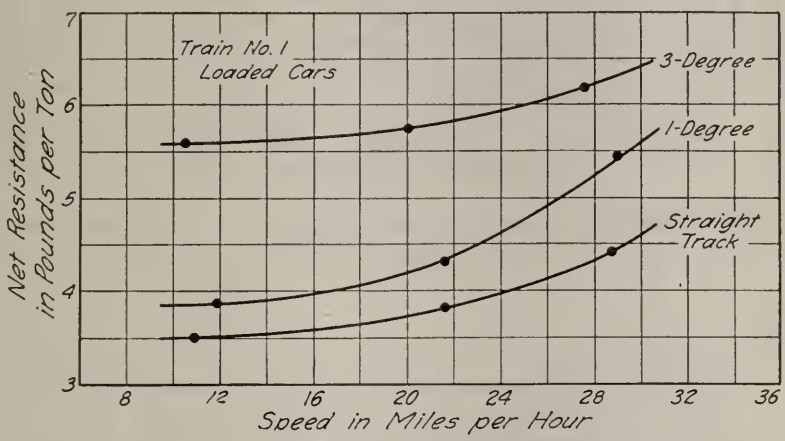


Fig. 8. Net Train Resistance for Train No. 1 on Straight Track and Both Curves

In Fig. 8 the three lines cross the ordinate corresponding to the speed of 10 miles per hour at points whose resistance values are 3.50, 3.85, and 5.59 pounds per ton, which are, respectively, the values of resistance for train No. 1 on the straight track, the one-degree curve, and the three-degree curve. These values are assembled in Table 4, in the first line of columns 3, 4 and 5; and the values for speeds of 20 and 30 miles per hour, similarly determined, are assembled in this table, in the second and third lines respectively. For the other trains, similar values of resistance on the tangent and the curves, derived from Figs. 9, 10, 11 and 12, are likewise presented in Table 4.

The differences between these tabulated values give the final values of curve resistance. Recurring to the resistance values for train No. 1 at 10 miles per hour, just cited, we find the resistance on the one-degree curve to be 3.85 pounds per ton and on the tangent 3.50 pounds; the difference, 0.35 pounds per ton, is the resistance due to the curvature on the one-degree curve. Since in this instance the curvature is one degree, this value (0.35) is likewise the final value of curve resistance in pounds per ton per degree.

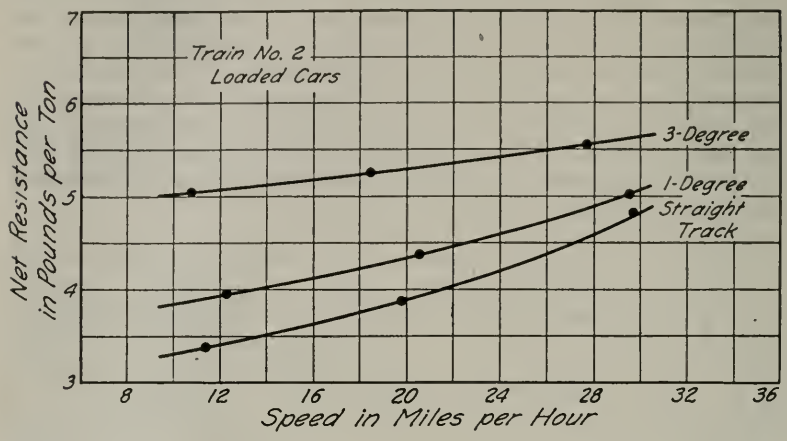


Fig. 9. Net Train Resistance for Train No. 2 on Straight Track and Both Curves

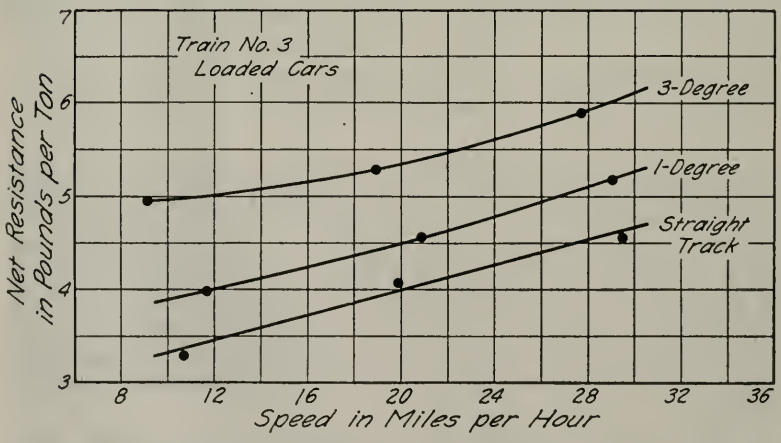


Fig. 10. Net Train Resistance for Train No. 3 on Straight Track and Both Curves

On the three-degree curve the resistance is 5.59, and the difference between this and 3.50 (resistance on the tangent) gives 2.09 pounds per ton as the total resistance due to curvature; in this instance, the curvature being 3.0 degrees, the value of curve resistance is $2.09 \div 3 = 0.70$ pounds per ton per degree. Similar values of resistance due to curvature, similarly derived, for all trains and all speeds, are given in columns 6 and 7 of Table 4. The

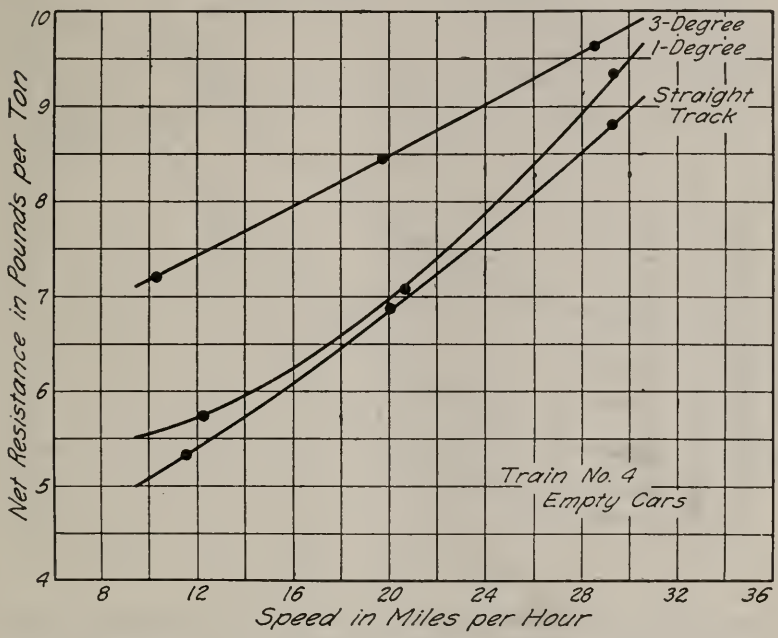


Fig. 11. Net Train Resistance for Train No. 4 on Straight Track and Both Curves

final values of curve resistance (found by dividing the values in columns 6 and 7 by 1.0 and 3.0, respectively) are presented in columns 8 and 9 of this table. These are the final results of this investigation.

These final results are reassembled in Table 5 in somewhat more convenient form. In this table the curve resistance, expressed in pounds per ton per degree of curve, is given for each of the five trains in the first five lines of the table. The sixth line presents the average values of curve resistance at the three speeds for all trains; and the last line gives the average results on each curve for all trains, when speed distinctions are ignored.

14. **The Final Results in Graphical Form.**—By plotting the values of curve resistance for each of the trains, as given in Table 5, we obtain the diagrams of Fig. 13—the upper diagram giving the final results on the one-degree curve, and the lower diagram, on the three-degree curve. In this

figure the the lines marked "average" show, for each curve, the average values of curve resistance for all five of the trains. The numerals on the lines in Fig. 13 are the train numbers. Fig. 13, like Table 5, presents the final results of these tests.

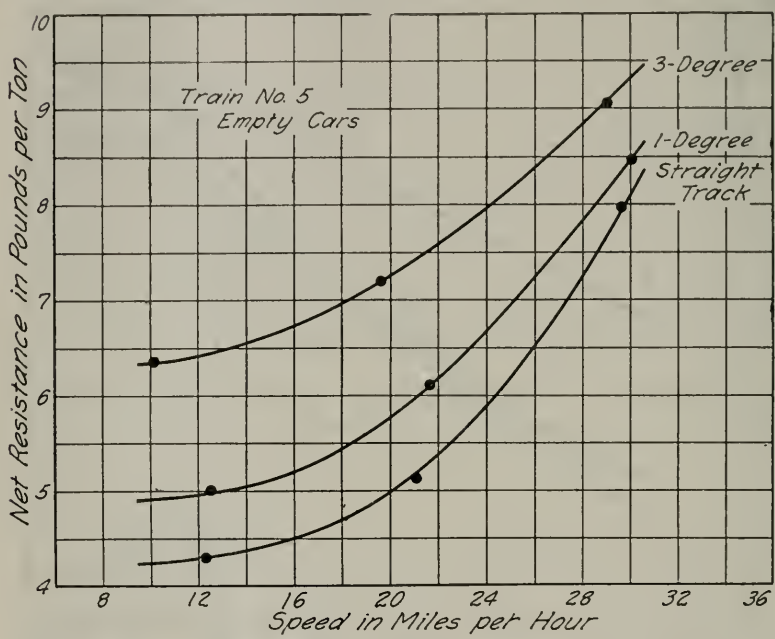


Fig. 12. Net Train Resistance for Train No. 5 on Straight Track and Both Curves

V. DISCUSSION OF THE RESULTS

15. **Divergence Among the Final Results.**—Inspection of the final results, as exhibited in Fig. 13, discloses a considerable divergence among them on the one-degree curve, the minimum value of curve resistance being 0.12 of a pound per ton per degree, and the maximum value, 1.0 pound. On the three-degree curve there is less divergence.

Reasons for this divergence have been sought in the following differences in the trains and in the conditions under which they were operated, namely:

(a) Difference in the average weight of the cars composing the trains.
(b) Difference in truck construction.
(c) Difference in wind resistance.
(d) Difference in the condition of the rail—whether dry or wet.

TABLE 4—VALUES OF RESISTANCE ON THE STRAIGHT TRACK AND ON THE CURVES AT 10, 20 AND 30 MILES PER HOUR, AND THE DERIVED VALUES OF CURVE RESISTANCE

Train Nos.	Speed m.h.p.	Resistance on the Straight Track and on the Curves. Pounds per Ton			Total Resistance Due to Curvature Pounds per Ton		Curve Resistance Lb. per Ton per Degree	
		On the Straight Track	On the One-Degree Curve	On the Three-Degree Curve	On the One-Degree Curve — Col. 4—Col. 3	On the Three-Degree Curve — Col. 5—Col. 3	On the One-Degree Curve — Col. 6÷1.0	On the Three-Degree Curve — Col. 7÷3.0
1	2	3	4	5	6	7	8	9
1	10	3.50	3.85	5.59	0.35	2.09	0.35	0.70
	20	3.73	4.20	5.75	0.47	2.02	0.47	0.67
	30	4.60	5.60	6.43	1.00	1.83	1.00	0.61
2	10	3.30	3.84	5.02	0.54	1.72	0.54	0.57
	20	3.89	4.35	5.30	0.46	1.41	0.46	0.47
	30	4.83	5.08	5.64	0.25	0.81	0.25	0.27
3	10	3.33	3.90	4.97	0.57	1.64	0.57	0.55
	20	4.00	4.50	5.36	0.50	1.36	0.50	0.45
	30	4.67	5.27	6.11	0.60	1.44	0.60	0.48
4	10	5.09	5.55	7.16	0.46	2.07	0.46	9.69
	20	6.85	6.97	8.48	0.12	1.63	0.12	0.54
	30	8.96	9.48	9.83	0.52	0.87	0.52	0.29
5	10	4.25	4.91	6.35	0.66	2.10	0.66	0.70
	20	4.99	5.74	7.25	0.75	2.26	0.75	0.75
	30	8.08	8.47	9.31	0.39	1.23	0.39	0.41

TABLE 5—THE FINAL VALUES OF CURVE RESISTANCE, AT VARIOUS SPEEDS FOR EACH OF THE FIVE TRAINS, AND THE AVERAGE VALUES FOR ALL TRAINS

Train Numbers	Curve Resistance—Pounds per Ton per Degree					
	On the One-Degree Curve			On the Three-Degree Curve		
	10 m. p. h.	20 m. p. h.	30 m. p. h.	10 m. p. h.	20 m.p.h.	30 m. p. h.
1	0.35	0.47	1.00	0.70	0.67	0.61
2	.54	.46	.25	.57	.47	.27
3	.57	.50	.60	.55	.45	.48
4	.46	.12	.52	.69	.54	.29
5	.66	.75	.39	.70	.75	.41
Average for All Trains.....	.52	.46	.55	.64	.58	.41
Average, Disregarding Distinctions in Speed		.51			.54	

While car weight influences net resistance, it does so chiefly through its effect on journal friction, and this effect is nearly, if not quite, the same on straight track and on curves. The effect will consequently not appear in the curve resistance, which is derived by subtracting the resistance on straight track from the resistance on the curve. Nevertheless, a reason for the divergence among the results has been sought in the difference in car weight by averaging the results separately for the three loaded trains and the two empty trains. These averages are tabulated below.

Average Values of Curve Resistance for the Loaded and the Empty Trains—Pounds per Ton per Degree

Train Numbers	Average Car Weight Tons	On the One-Degree Curve			On the Three-Degree Curve		
		10 m.p.h.	20 m.p.h.	30 m.p.h.	10 m.p.h.	20 m.p.h.	30 m.p.h.
Nos. 1-2-3 Loaded Cars	48.6	.49	.48	.62	.61	.53	.45
Averages			.53			.53	
Nos. 4-5 Empty Cars	15.1	.56	.44	.46	.70	.65	.35
Averages			.48			.56	

There is nothing in the relations between these values to warrant the inference that variation in car weight is responsible for the variation in the results of the tests.

The trucks in the different trains differed in the stiffness of their construction, and this might have affected the curve resistance. The trucks on trains 3 and 5 were identical and less stiff than the others. While the values for train 5 are high on both curves, those for train 3 are normal on the one-degree curve and slightly low on the three-degree curve; and no satisfactory explanation of the divergence among the results may be drawn from these facts.

The possible influence of wind resistance is obvious; but a detailed study of the original wind data discloses no tenable explanation for the variation among the lines of Fig. 13.

All theories of curve resistance agree in ascribing it to the work absorbed by friction between the rail head and the flanges and treads of the wheels; and it would seem probable that when these surfaces are wet, the lubricating effect of the water would reduce the curve resistance. Of the 101 tests upon whose results this report is based, seven were run on wet rails; and of these seven tests five are included among the eleven tests run with train

No. 1 at 30 miles per hour. The values of curve resistance for this train at this speed have been separately calculated for the tests on the wet rail and for those on the dry rail, with the following results:

Curve Resistance of Train No. 1 at 30 Miles per Hour—Pounds per Ton per Degree

	On the One-Degree Curve	On the Three-Degree Curve
Average for the 5 tests run on wet rail	0.87	0.57
Average for the 6 tests run on dry rail	1.17	0.65
Average for all 11 tests (as in Table 5)	1.00	0.61

The relation between these values lends some support to the inference drawn above, namely, that curve resistance is probably diminished when rails and wheels are wet. The showing does not, however, help to explain the divergence among the test results exhibited in Fig. 13; for, instead of having a low curve resistance, train No. 1 at 30 miles per hour has a higher resistance on both curves than any other train. Whatever may be the

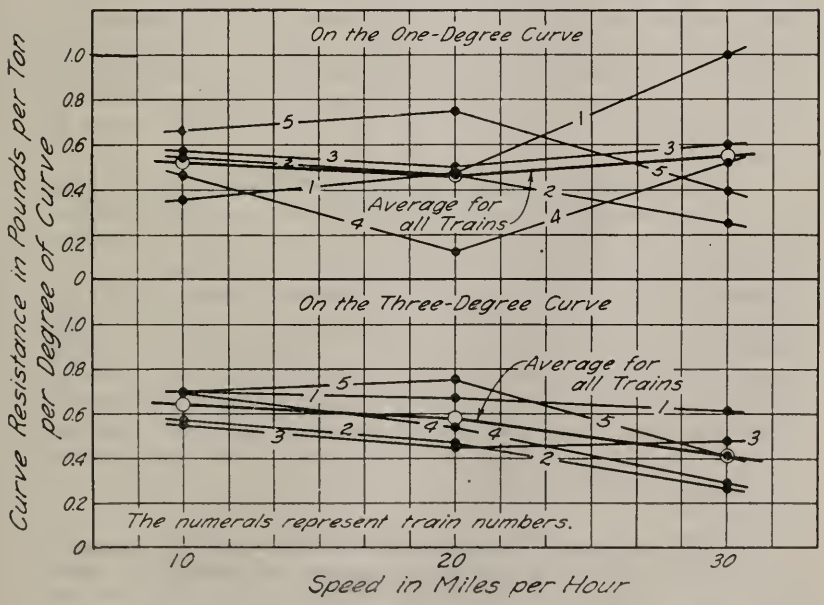


Fig. 13. Curve Resistance at 10, 20 and 30 Miles per Hour for Each of the Five Trains, and the Average Values for All the Trains

influence of the wet rail, it has obviously been overtopped in this instance by some other influence.

It is a common experience in measuring train resistance to find that for a given train, it will vary from time to time even under conditions which are apparently identical. Such variation is commonly attributed to momentary changes in flange resistance and oscillatory resistances; and if any of the divergent points of Fig. 13 were based upon one test only, its divergence could plausibly be attributed to such changes. There is in Fig. 13 only one point based on a single test—the one which defines the curve resistance for train No. 3 at 10 miles per hour; but this point in the diagram for the one-degree curve nearly coincides with the average for all trains, and on the diagram for the three-degree curve it is not notably divergent. All other values plotted in Fig. 13 are averages of the results from three or more tests, and, consequently, the momentary or periodic variations in train resistance referred to above offer no acceptable explanation for the variation in the test results.

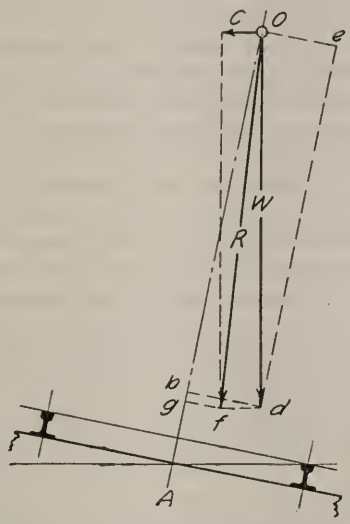
The information at our disposal seems inadequate to account for the differences in the curve resistance of the five trains as exhibited in Table 5 and Fig. 13. Some of the variation may be due to inaccuracies in the test appliances and methods; but much of it must be regarded as unaccounted for, and likely to be encountered in trains in service. The total range in curve resistance for all tests is from a minimum of 0.12 of a pound to a maximum of 1.00 pound per ton per degree of curve. If from the results on the one-degree curve we exclude the two most divergent—those for train 1 at 30 m.p.h. and for train 4 at 20 m.p.h.—the general range in the value of curve resistance on both curves is from 0.25 to 0.75 of a pound per ton per degree.

16. **The Influence of Track Curvature.**—The best available measure of the influence of track curvature on curve resistance afforded by these tests is the average result for all trains, irrespective of speed. This average is presented in the last line of Table 5. For the one-degree curve it amounts to 0.51 of a pound per ton per degree of curve; and for the three-degree curve, 0.54 of a pound per ton per degree. Obviously the only conclusion to be drawn from these results is that the sharpness of the curve has no effect on curve resistance expressed in pounds per ton per degree of curve. Whether this conclusion would hold good for curves of a curvature greater than three degrees cannot be determined from these tests. It is to be regretted that the test program did not include tests on curves of greater curvature; but, as has been intimated, it was impracticable to do so.

17. **The Influence of Speed on Curve Resistance.**—If in Fig. 13 we confine our attention to the lines representing the average curve resistance for all five trains, we find on the one-degree curve no regular variation of curve resistance with speed. From 10 miles per hour to 20 miles per hour the curve resistance decreases, but it increases as we pass from 20 to 30 miles per hour. If, however, we exclude from consideration the

apparently abnormal value for train No. 1 at 30 miles, the curve resistance constantly declines with speed, and at a fairly uniform rate—the values being 0.52, 0.46 and 0.44 at 10, 20 and 30 miles per hour, respectively. Considering the individual trains on the one-degree curve we find no regularity in the variation with speed, except for train No. 2.

On the three-degree curve the average values of curve resistance decrease regularly with the speed, being respectively, 0.64, 0.58 and 0.41; the rate of decrease between 10 miles and 20 miles is the same as on the one-degree curve, but between 20 and 30 miles it is considerably greater. Three of the individual trains show on the three-degree curve a similar decrease of resistance with speed; but trains 3 and 5 present results which vary irregularly.



While the data do not warrant an unqualified conclusion concerning the influence of speed, they do support the inference that in passing from 10 to 30 miles per hour there is, in general, a decrease in curve resistance on both curves. The well-known action of the wheel flanges on curves, and common experience in operating freight trains on curves super-elevated for high speed trains also support this inference—for the reasons developed below.

On any curve whose outer rail is super-elevated there is, for any car, one speed of operation at which the car trucks have no more tendency to run toward either rail than they have on straight track, where both rail-heads are at the same level. At lower speeds the trucks tend constantly to run down against the inside rail of the curve, and thereby increase the flange friction; while at higher speeds they run toward the outer rail, with the same effect. This may be made clearer by reference to the accompanying diagram, which represents the forces which operate on a car at its center of

gravity (0). With the car at rest on the curve there is a component of the weight (W) which tends to move the car down toward the inner rail. This component is represented by the line Oe, equal to bd. When the car moves along the track centrifugal force (C) comes into play, and the car action is controlled by the force R, which is the resultant of W and C. The force R likewise has a component (gf) which, although smaller than bd, still tends to move the car toward the inner rail. This tendency persists until, with increasing speed, the value of C becomes great enough to cause the line of operation of R to coincide with OA, the center line of the track perpendicular to the plane of the rail. At this critical or balancing speed the component gf is reduced to zero and there is no longer any tendency of the trucks to run toward either rail. If the speed be still further increased, the component gf arises again, but now on the opposite side of the center line OA and of opposite sense, causing the trucks to tend toward the outer instead of the inner rail and thereby reviving the extra flange friction. It should be emphasized that the flange friction arising from the play of the forces here under discussion is distinct from, and in excess of, the flange friction which arises from the action of the flanges in forcing the truck to follow the track curvature. This excess being a variable element of curve resistance, we may expect to find that curve resistance reaches a minimum value when this excess reduces to zero, that is, when the car speed reaches the critical value above referred to.

This critical speed depends only on the super-elevation, the track gauge, and the radius of track curvature. Using the appropriate values for these quantities, the critical speeds have been calculated for these tests and found to be 36 miles per hour on the one-degree curve, and 43 miles per hour on the three-degree curve. Since curve resistance probably reaches its minimum value at these speeds, and since they both lie beyond the maximum speed attained on any of the tests, we might expect to find that, within the range of the test speeds, there would be a general decrease of curve resistance with speed such as has been disclosed in the discussion of Fig. 13.

18. **The Applicability of the Results in Freight Service.**—Question may very properly be raised as to whether the results of these tests are generally applicable to all ordinary freight trains or whether, because of some of the conditions surrounding the tests, their results are limited in their application. The conditions with respect to which such doubt may be entertained are:

(a) The track construction. It was inferior to that of most main line track.
(b) The average load per car varied from 15.1 to 48.6 tons—a little more than one-half of the usual freight service range.
(c) The weather was warm.
(d) The wear of the rails may not be typical.
(e) The super-elevation may differ from that usually encountered.

The first three of these items may be disposed of in the same manner and they are therefore considered together. Rail, weight and general track construction can influence only two elements of train resistance, namely, rolling resistance and the so-called track resistance. Average weight per car influences resistance only through its effect on journal friction. The air temperature, likewise, influences resistance through its effect on journal friction. All three of these effects will undoubtedly be of the same magnitude on straight track and on the curve. Suppose, for illustration, that any of the trains had been run on better track and that consequently the net resistance on straight track would have been, say, one-half pound per ton less than it actually was during the tests, under some particular set of conditions. It seems certain that under these same conditions, on the curved track, the total resistance on the curve would likewise have been one-half pound less than it actually was during the tests. In deriving curve resistance, however, we subtract resistance on straight track from total resistance on the curve, and in this process the half-pound difference referred to would obviously disappear, and the resulting value of curve resistance would have been the same as it actually was on the inferior track. The same sort of argument may be applied to the effects of car weight and air temperature—and the same conclusion drawn. We may therefore conclude that the test results are equally applicable to track of varying excellence of construction, to the entire range of car weight encountered in service, and to winter as well as summer temperatures.

There are reasons for assuming that curve resistance is affected by the condition of the rail-head, as regards its wear. While there is, obviously, no standard of rail wear with which the wear of the rails on the test curves may be compared, inspection of Fig. 14 indicates that, under general practice, the rails were not ready to be replaced, that they may be regarded as having served about one-half their life, and that they are consequently in "average" condition.

The effect of super-elevation has been discussed in the preceding section, the discussion indicating that excessive super-elevation will cause an increase in curve resistance up to the critical or balancing speed, which lies generally beyond the maximum speed of freight trains. While practice varies considerably, super-elevation lies usually between the limits of ¾″ and 1″ per degree of curve. On the one-degree curve of the test track the average super-elevation, 0.89″, lies within these limits. On the three-degree curve, however, the super-elevation was 3.71″, which is in excess of these ordinary limits. We may infer therefore that the curve resistance results on the three-degree curve are slightly greater than those ordinarily to be encountered on curves of this curvature.

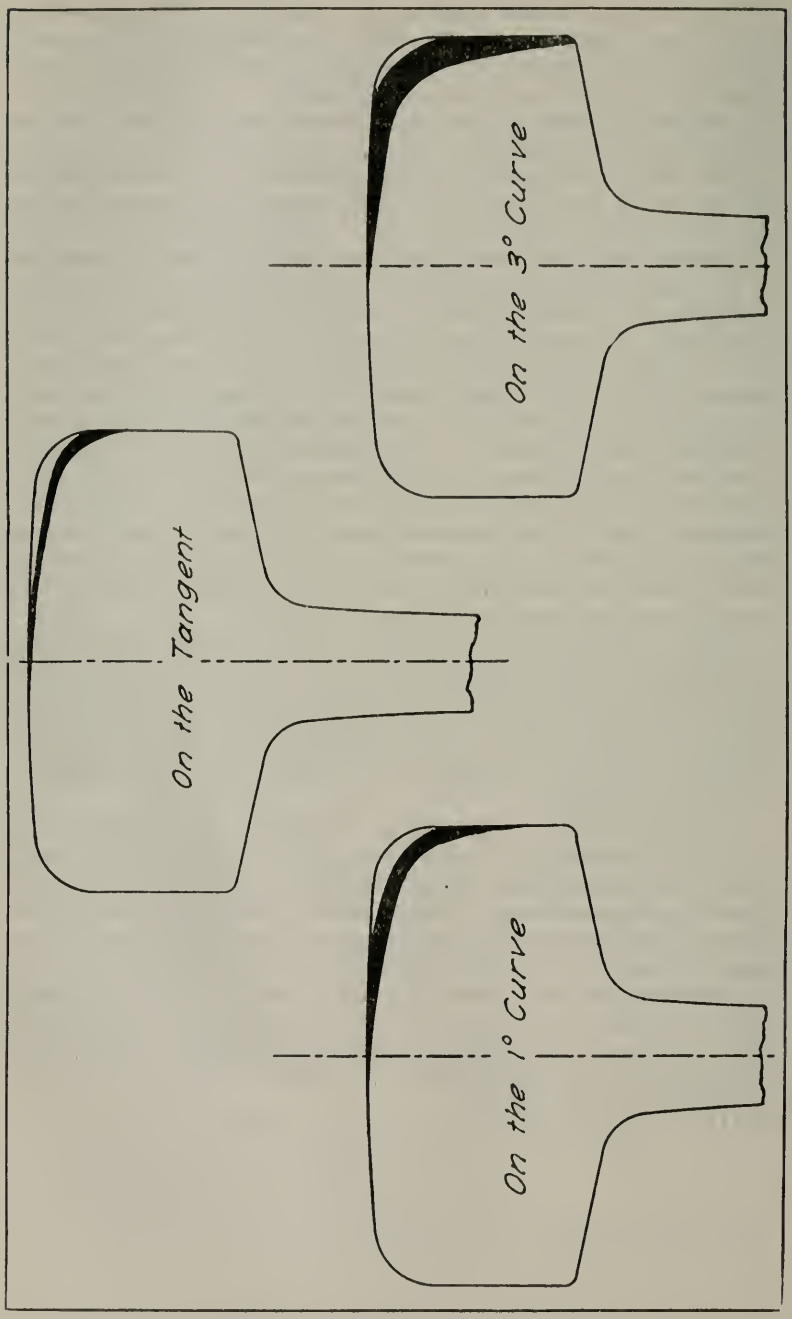


Fig. 14. Contour Limits of the Worn Rail Heads on the Tangent and the Curves

VI. SUMMARY

The bulletin presents the results of 101 tests made with five freight trains in order to find the excess of their resistance on curve track over that on straight track. This excess, termed curve resistance, was determined on a one-degree curve and a three-degree curve; it is expressed throughout in pounds per ton per degree of curve. On each curve tests were made with each train at three speeds—nominally 10, 20 and 30 miles per hour.

The tests were made on track of fair construction, laid with 70-lb. rails. The average gross weight of the cars composing the test trains varied from 15.1 tons to 48.6 tons. The tests were run during warm weather, the air temperature varying from 62 to 95 degrees Fahr. During only two tests did the wind velocity exceed 15 miles per hour. All but seven of the tests were run when wheels and rails were dry.

The average values of curve resistance derived from the test results are presented in Table 5 and in Fig. 13. Both the table and the figure give the results for each train at each of the three speeds, and also the average results for all trains. All the results apply to periods during which the entire train ran upon curved track.

On the one-degree curve the average curve resistance amounted to 0.52, 0.46 and 0.55 pounds per ton per degree of curve, at speeds of 10, 20 and 30 miles per hour, respectively. On the three-degree curve it amounted to 0.64, 0.58 and 0.41 pounds per ton per degree at the respective speeds. Disregarding distinctions in speed, the general average curve resistance for all trains was 0.51 pounds per ton per degree on the one-degree curve, and 0.54 pounds per ton per degree on the three-degree curve.

Since the super-elevation on the three-degree curve was a little greater than is customary, it is probable that the results for this curve are somewhat greater than the curve resistance ordinarily to be encountered on this curvature. The excess is probably slight.

Excluding the results obtained on the one-degree curve with one train at 30 miles per hour, the average results for all trains show, on both curves, a decrease in curve resistance as the speed increases. The rate of decrease is not great, nor is it uniform.

The general average curve resistance, disregarding speed distinctions, was practically the same on the two curves. The test results offer no clue as to whether the curve resistance would have varied with track curvature had it been practicable to test the trains on a greater variety of curves.

The few tests run on wet rail afford some evidence that curve resistance is diminished when rails and wheels are wet.

The analysis of the results presented in Section V indicates that they may safely be applied to predict the curve resistance of all freight trains, running on either good or poor track, and under either summer or winter temperatures. It is not certain whether the results are applicable to track curvatures much in excess of three degrees.

Appendix 1

THE IMMEDIATE RESULTS OF THE TESTS

The immediate results of the tests are embodied in Tables 6, 7, 8, 9 and 10 of this Appendix. As has been indicated, the calculations made from the original test data provide, for each test, a value of mean resistance and a corresponding value of mean speed on the straight track, a similar pair of values on the one-degree curve, and a third pair on the three-degree curve. Tables 6 to 10 present these values of resistance and speed for each of the five trains. The values are arranged in the tables in three groups, one group for each of the three speeds at which the tests were run—nominally 10, 20 and 30 miles per hour.

The tables also show for each of the groups the average values of resistance and speed for all tests included in the group. These average values are the co-ordinates of the points plotted in Figs. 8 to 12 in the body of the bulletin.

TABLE 6—VALUES OF RESISTANCE AND SPEED OBTAINED FROM THE TESTS MADE WITH TRAIN NO. 1

Nominal Speed — m.p.h.	Test Numbers	On the Straight Track		On the One-Degree Curve		On the Three-Degree Curve	
		Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h	Resistance Lb.perTon	Speed m.p.h.	Resistance Lb. per Ton
10	135	11.10	3.64	12.12	3.01	10.64	5.15
	136	10.62	3.67	12.20	4.32	9.95	5.75
	137	11.18	3.65	11.87	4.21	10.17	5.77
	138	10.91	3.67	11.68	4.33	10.06	5.99
	139	10.34	3.67	10.83	3.97	10.12	6.15
	146	10.97	2.69	12.24	3.29	12.24	4.70
Average	Values.....	10.85	3.50	11.82	3.86	10.53	5.59
20	127	21.64	3.99	21.43	4.87	20.95	5.92
	128	22.09	3.90	21.48	4.33	20.32	5.28
	129	23.32	4.30	23.20	4.16	20.52	6.43
	130	20.77	3.84	20.76	4.31	19.20	6.18
	131	21.28	3.84	21.60	4.58	19.65	5.81
	132	21.06	3.15	20.81	3.88	19.13	4.82
	133	22.08	3.60	22.24	4.14	20.63	5.49
	134	21.50	3.95	21.89	4.59	20.54	6.34
	145	20.84	3.85	20.83	3.99	19.26	5.52
Average	Values.....	21.62	3.82	21.58	4.32	20.02	5.75
30	117	25.90	4.33	26.42	5.63	25.22	5.41
	118	27.82	5.26	27.93	6.13	25.90	6.44
	119	28.25	3.90	28.55	4.41	26.40	5.81
	120	28.13	4.49	28.75	5.32	27.25	6.97
	121	28.85	5.00	29.25	5.61	27.20	6.57
	122	29.34	4.97	29.49	5.31	28.21	6.27
	123	28.00	3.55	28.46	5.04	27.00	5.66
	124	30.05	4.01	29.96	6.04	29.60	5.67
	125	30.25	4.86	30.27	5.39	29.45	6.60
	142	29.77	4.23	29.95	5.52	28.40	6.31
	144	29.70	4.01	29.98	5.51	28.76	6.39
Average	Values.....	28.73	4.42	29.00	5.45	27.58	6.19

TABLE 7—VALUES OF RESISTANCE AND SPEED OBTAINED FROM THE TESTS MADE WITH TRAIN NO. 2

Nominal Speed — m.p.h.	Test Numbers	On the Straight Track		On the One-Degree Curve		On the Three-Degree Curve	
		Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton
10	28	11.56	3.47	11.92	4.08	10.54	5.36
	55	11.20	3.38	12.20	3.84	10.36	4.92
	56	11.46	3.29	12.74	3.92	11.10	4.84
Average	Values.....	11.41	3.38	12.29	3.95	10.67	5.04
20	8	16.47	3.94	17.89	4.49	16.39	5.84
	10	17.75	3.98	18.45	4.41	15.08	5.57
	12	17.92	4.11	18.83	4.62	16.10	5.73
	26	20.06	4.22	21.18	4.59	18.60	4.58
	27	20.13	4.13	20.42	4.92	18.62	4.97
	42	19.83	3.79	20.43	4.28	18.77	5.58
	48	23.02	3.86	23.24	4.31	21.12	5.24
	49	21.21	3.66	21.78	4.12	19.33	5.57
	51	20.59	3.80	21.70	4.25	20.36	4.86
	52	20.50	3.28	20.95	4.11	18.93	4.96
	54	20.33	3.90	21.13	4.15	19.45	4.90
Average	Values.....	19.80	3.88	20.55	4.39	18.43	5.25
30	4	28.70	6.02	28.00	6.02	24.76	5.86
	6	30.34	5.31	30.49	4.55	28.89	5.82
	31	27.97	5.50	28.37	4.88	25.98	6.12
	43	30.72	4.67	30.60	4.79	28.96	5.40
	44	30.44	4.03	29.55	5.03	27.69	5.21
	45	28.71	3.88	28.89	4.60	27.54	4.69
	47	31.42	4.23	30.85	4.91	29.05	5.45
	50	29.71	4.90	30.00	5.36	29.03	5.83
Average	Values.....	29.75	4.82	29.59	5.02	27.74	5.55

TABLE 8—VALUES OF RESISTANCE AND SPEED OBTAINED FROM THE TESTS MADE WITH TRAIN NO. 3

Nominal Speed — m.p.h.	Test Numbers	On the Straight Track		On the One-Degree Curve		On the Three-Degree Curve	
		Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton
10	24	10.73	3.29	11.64	3.99	9.06	4.95
20	19	21.90	4.49	22.78	4.26	19.98	6.40
	21	22.22	4.37	23.30	5.22	20.65	5.23
	57	17.66	4.51	19.35	4.99	17.63	5.65
	62	20.41	4.12	20.88	4.82	18.36	5.60
	66	19.67	3.74	20.93	4.01	18.97	4.79
	67	20.20	3.88	21.10	4.50	19.62	4.60
	68	18.76	3.94	19.25	4.40	17.33	5.15
	69	18.48	3.54	19.46	4.18	18.65	4.88
	70	19.80	3.93	20.61	4.70	18.88	5.27
Average	Values.....	19.90	4.06	20.85	4.56	18.90	5.29
30	18	32.44	4.11	28.86	4.46	26.72	5.18
	20	29.08	4.97	28.66	4.67	27.32	4.85
	23	27.72	4.95	28.05	5.32	26.55	5.79
	58	28.92	4.28	28.92	5.66	27.49	5.26
	59	29.34	4.48	29.79	5.42	28.59	7.17
	60	30.80	4.69	30.52	5.31	29.12	6.59
	63	28.91	4.36	28.77	5.19	28.05	6.02
	64	28.68	4.65	28.80	5.48	27.73	6.30
Average	Values.....	29.49	4.56	29.05	5.19	27.70	5.90

TABLE 9—VALUES OF RESISTANCE AND SPEED OBTAINED FROM THE TESTS MADE WITH TRAIN NO. 4

Nominal Speed — m.p.h.	Test Numbers	On the Straight Track		On the One-Degree Curve		On the Three-Degree Curve	
		Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton
10	90	11.20	5.69	11.32	5.18	10.63	7.30
	91	11.32	5.63	12.76	6.02	10.85	7.75
	92	11.37	5.61	11.68	5.95	9.82	7.17
	93	11.92	4.73	12.71	5.42	10.22	6.66
	94	12 04	4.99	12.81	6.15	10.15	7.14
Average	Values.....	11.57	5.33	12.26	5.74	10.33	7.20
20	82	20.59	7.13	20.89	7.29	19.07	8.70
	83	20.58	6.26	21.12	6.45	20.25	8.24
	84	19.79	6.72	21.15	7.04	19.90	8.41
	86	20.49	7.96	20.17	7.93	20.10	8.55
	88	18.91	6.29	19.95	6.57	19.60	8.34
Average	Values.....	20.07	6.87	20.66	7.06	19.78	8.45
30	73	28.53	8.57	28.46	9.62	27.35	9.26
	74	29.28	9.43	29.92	10.83	29.17	10.42
	75	29.54	9.37	29.31	10.65	28.69	10.50
	76	29.32	9.98	29.43	9.89	29.15	10.33
	77	29.10	8.70	29.93	9.33	28.27	9.59
	78	29.39	8.86	29.34	9.59	28.63	10.01
	79	30.15	7.99	29.41	7.46	28.82	8.13
	80	29.01	7.49	29.13	7.31	28.34	8.77
Average	Values.....	29.29	8.80	29.37	9.34	28.55	9.63

TABLE 10—VALUES OF RESISTANCE AND SPEED OBTAINED FROM THE TESTS MADE WITH TRAIN NO. 5

Nominal Speed — m.p.h.	Test Numbers	On the Straight Track		On the One-Degree Curve		On the Three-Degree Curve	
		Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton	Speed m.p.h.	Resistance Lb. per Ton
10	112	12.25	4.17	12.26	4.35	10.10	5.72
	113	13.86	3.93	14.05	4.52	10.37	5.88
	114	12.15	4.40	12.55	5.04	10.23	6.38
	115	11.35	4.74	11.75	6.20	9.80	7.34
	116	11.86	4.19	11.91	4.87	9.97	6.44
Average	Values.....	12.29	4.29	12.50	5.00	10.09	6.35
20	107	20.90	5.34	21.46	5.85	20.30	7.40
	108	22.06	5.37	22.41	6.77	20.27	8.01
	109	20.83	4.92	21.33	6.05	19.05	6.87
	110	21.32	4.98	21.70	6.13	19.45	7.30
	111	20.42	5.06	21.43	5.73	19.10	6.40
Average	Values.....	21.11	5.13	21.67	6.11	19.63	7.20
30	96	28.63	8.01	29.09	9.01	28.31	9.42
	98	31.33	8.36	31.68	9.96	30.30	9.78
	99	29.68	7.98	30.23	8.40	29.20	8.44
	100	29.10	7.85	29.23	8.19	29.00	8.78
	101	28.93	8.11	29.40	8.54	28.50	9.24
	102	29.30	7.72	29.70	7,50	28.35	8.85
	104	30.71	7.78	31,02	7.68	29.65	8.90
Average	Values.....	29.67	7.97	30.05	8.47	29.04	9.06

THE HIGHWAY GRADE CROSSING PROBLEM

By Robert H. Ford,

Assistant Chief Engineer, Rock Island Lines

The highway system of the United States has undergone a most rapid and startling transformation within the last few years until it has now become one of the principal transportation agencies of the country. This, in turn, has resulted in complicating the highway grade crossing situation and makes it one of the most important problems confronting the American public today, largely because of the wide diversity of interests and political jurisdictions under which the highway system is supervised and controlled.

Before the advent of the automobile, the highway mileage consisted largely of public pathways meandering through the country without respect to curvature or gradients and with little regard for principles of economic location. The main thing was to permit horse-drawn vehicles eventually to reach their destination. Time and convenience, as understood today, were given little consideration, and except at special locations, the safety factor was not serious because of the slow vehicular movement.

Highway maintenance was in keeping with methods of location. The sun and wind were the two principal agencies, except in the larger communities. A vast mileage also served as a convenient medium for the farmer to work out his taxes. He could devote a few days now and then with his farm wagon in filling up the holes in the road, or in making crude repairs to the smaller bridges spanning the waterways.

But, overnight, as it were, a great mileage of modern highways has been developed. Roads have been transformed from country lanes into broad thoroughfares, graded, drained, and paved in the most approved fashion, and constructed at costs which rival the cost per mile of a modern steam railroad, with track, bridges and signals complete.

The public highways of the United States may be grouped about as follows:

(1) **City Streets.**—Wholly within the control of municipalities, and supervised and directed by approximately 3100 independent organizations.

(2) **Boulevards and Park Roads.**—Controlled by park commissioners and usually independent of municipal authorities with respect to standards, public markings, maintenance, etc. There are approximately 3000 principal commissions of this character in our larger centers.

(3) **County Roads.**—Under the control of county judges, road commissioners, etc. Independent of each other and of any central body, and subject to their own views with respect to location of the roads and grade crossings thus created or closed, safety and convenience of the public, highway markings and standards, character of maintenance, etc. There are about 145,000 of these separate bodies in the United States in charge of highways.

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(4) State Highways.—More or less under the control of state highway commissions and independent of municipal or county authorities. One in every State, or forty-eight commissions. Each state commission is a law unto itself with respect to location of roads or crossings, standards of maintenance, highway markings, etc.

(5) Federal Roads and Highways.—Controlled by Federal agencies, and except for the State-aid roads, more or less independent of state, county or municipal authorities.

From the foregoing it will be seen that our highway systems are in the hands of over 150,000 unrelated bodies more or less independent of each other and political in their composition, except as they may, from time to time, delegate their powers to persons competent by training and experience in such matters.

It is not difficult, therefore, to understand why our grade crossing situation both at highway and railway intersections is in such a chaotic state. Also why our highway marking system is so widely different over the country, to the utter confusion of the traveller, or why there is no uniformity of standards for protection at railway grade crossings. The excellent systems in some sections are neutralized by complete reversals of practices in other sections—to the bewilderment and danger of the highway user.

It also serves to throw some light on the reason why in 1926 there were 600,000 people injured and 20,819 killed in accidents on highways and at highway intersections; and 6991 persons injured and 2492 killed at railroad crossings in the United States.

Railroads Are Public Property

While the railway system will probably always remain the principal agency for transport, the newly developing highway system is of equal importance to the public, and is used by a vastly greater number of persons than either the waterways or the railways for profit and pleasure. These three systems comprise the great transportation mediums of the country.

There is, in many respects, a striking similarity in the development of the American railway system and the fundamentals of the national highway system. From small beginnings the railroads developed during the past 100 years until they now form a vast network spreading out over the States, and comprising 258,000 miles of main lines, feeder and branch lines equivalent to 8.68 miles per 100 square miles of area. The American railway system now rivals in every respect all transportation mediums of the entire world, a result which has been successfully accomplished in the face of steadily rising costs and without subsidy or assistance from Federal, State or other public agencies. This is the direct opposite for its rivals, the waterways and highways transport system.

The three transport systems are essentially for public use and are owned by the public irrespective of the popular notion that its railway system is a private organism, for while true in a legal or technical sense, it is not so in public application. The fact is that 94 per cent of railway

ownership is distributed among hundreds of thousands of small holdings, or held in trust for the benefit of many millions of individuals, while its securities now form one of the principal repositories for the savings of the small investor and for their trust and reserve funds principally through the medium of insurance companies, estates and similar agencies. Ownership equities of the American railway system are in the hands of more than sixty millions of people and represent a much larger public holding than the securities of the public highway or water transport systems.

Railways Have Unified Control

Meanwhile the wages which the railways must pay; the conditions under which its employees shall work; the rates which they may charge for services and the form and character of this service, are controlled by the general public through Federal and State commissions set up for the purpose.

It will be seen, therefore, that the railways have, in reality, passed to public ownership in a much larger sense than many other public agencies and it is but a polite fiction to say that they are private organizations.

The American system of railway transport is directed by public opinion and so organized as to function as a single composite unit with respect to methods of operation, standards and practices of construction, maintenance and transportation. It works in close alliance with and functions through a dual organization consisting on the one hand of the Interstate Commerce Commission (representing the Government) and the state utility commission (representing the States) and on the other, through highly skilled railway administrators, developed by long processes of training and education in the science of transportation.

To keep this great system modernized and standardized there has been developed a powerful auxiliary force of experts who function as the American Railway Association, and who also work in close alliance with the Interstate and State commissions and the several railways or component parts of the national railway system. This expert organization is supervised by the executive officers of the individual roads and so subdivided and organized as to group together, for advisory purposes, specialists in every form of transport service, such as transportation, mechanical, engineering, signaling, maintenance, safety, etc. It is through these organizations that standardization and uniformity of practices are secured to keep the railway system in step with the needs of the country and immediately responsive in the production of safe and convenient transportation.

Highway System Not Co-ordinated

The highway system, in a similar sense, is also owned by the public, being one of its three great systems of transportation and equally necessary for its convenience. It is built and maintained by public funds and now comprises 2,862,197 miles of roads, exclusive of streets and park road mileage in communities with a population of 2000 or over. These roads may be divided as follows:

(1) The Federal-State, or Federal Aid Highway System, approximately	200,347 miles
(2) County, Township and other public roads	2,661,850 miles
Total	2,862,197 miles

In contrast with the railway transport system with its centralized operating agency and close working alliance with the general public through the Interstate and State railway commissions, the highway system is operated by a vast unwieldy body of unrelated organizations with continually changing personnel, and except for a relatively small portion of the total mileage, where the duties have been delegated to competent persons, there is only fragmentary knowledge of the economic problems with which these highway authorities are confronted. It is not surprising, therefore, that staggering sums of public funds are being wasted annually on the highways and that an enormous number of unnecessary accidents and casualties occur. These casualties would be greatly reduced if co-ordinated control of these political subdivisions were set up and the highway transport system co-ordinated and modeled, as far as practical, on the system which the public has built up for its railway transportation system.

Many Highways Are Unnecessary

Overnight, as it were, the horse-drawn vehicle has practically disappeared from the highways, to be replaced by the self-propelled vehicle of from five to twenty times the weight and three to ten times greater speed, and with maximum passenger and freight carrying capacities equivalent to railway coaches and freight cars.

This rapid change has made possible such great changes in highway transport as to render unnecessary and undesirable a vast highway mileage of the horse-drawn-vehicle age which now constitutes an enormous drain on the public treasury and an ever increasing burden for upkeep as well as outstanding menace to public safety. Their continuation is an economic public liability.

It has been stated by a prominent highway authority that with proper education and scientific planning, approximately 30 per cent of the county, township and miscellaneous highways would be unnecessary, and their abolition would reduce proportionately the number of existing highway intersections and railway crossings, and operate in turn to decrease the annual cost of maintenance with its excess burden of taxation, and what is more, decrease the annual toll of lives and casualties at grade crossings. A partial study in several western states seems fully to justify this statement.

Useless Roads Cause Heavy Tax Burden

Our system of indirect taxation makes it very difficult for the average citizen to realize how much better off he would be financially if this great burden of unnecessary highways with its incubus, the dangerous grade crossing, were taken from his back and the highway system properly correlated between trunk and feeder lines, unnecessary branches being lopped

off wherever their economic necessity cannot be shown. But the application of this principle will first require proper recognition of the economic advantage of properly correlated national railway, highway and water transport systems and relieve multitudinous highway bodies of their authority on standardization, maintenance and operation. This work should be delegated to a properly qualified state authority functioning through state utility commissions, who, in turn, should be required to work through a national authority associated with the Interstate Commerce Commission with respect to public policy in the production of safe and convenient highway transportation.

New Organization Proposed

It is a matter for serious consideration whether Federal highway aid should not be withheld until some satisfactory organization of this character has been properly developed by the states.

One of the practical results that this would doubtless accomplish would be to require a clearer and more comprehensive understanding of the strategic location and development for through trunk highways, and their relationship with secondary or feeder roads than now exists; as well as a more rational authority for their projection from Federal and State sources.

The more important secondary feeder lines would thus become tributary in fact to the trunk road, and bear the same relation that a feeder does to the main line of a railway. What is equally important, it would permit the prompt closing of branch roads and railway crossings as they become unnecessary through the development of the highway system, in much the same manner as branch line mileage is treated on the steam roads. With the railway, when their public necessity has ceased, such branches are torn up and not permitted to remain as a liability on the main system, whereas, with relatively few exceptions, the unnecessary branch highway liabilities continue.

Should Be Based on Thorough Study

The public has already expended enormous sums for the new and improved thoroughfares with vastly increased hauling and speed capacities, making distances no longer the comparable factor that they were heretofore.

Our unrelated highway system divides into three groups:

Group 1—Municipal streets and park roads.

Group 2—Interstate or Federal-State trunk highways.

Group 3—County, township and miscellaneous roads; and as previously shown, controlled by unrelated political sub-divisions with a large mileage in Group 1 and Group 3 rendered unnecessary by the development and improvement of the highways in Group 2. It is on the latter group that Federal and State highway funds have been principally expended.

It is apparent, therefore, that the Federal-State roads of Group 2, with suitable secondary or feeder connections from Group 1 and Group 3,

constitute the essence of the public highway system, to be fostered and developed as far as practicable in the same manner as the steam railway system has been developed in the same interest.

It is also in the collective interests of all parties that a thoroughly scientific study should be undertaken by a properly constituted national body working with the States, and the railway, highway and waterway interests, for the establishment of definite principles and methods for planning and developing a properly articulated national transport system.

The importance of this is further emphasized because of the close relationship of the highways to the railways and waterways. No such study has been undertaken in the newly developing highway system, for which the national and state treasuries are annually appropriating large sums of money. All three are being supported by the public at a staggering expense.

Crossings Continued on Obsolete Roads

A large mileage of these branch highways now obsolete through the building of the existing trunk system, carry their proportion of unnecessary grade crossings. These crossings are being continued although there is every reason why they should be closed; because, through lack of correlation, definite planning, and in the absence of any central authority, there is usually an insistent local demand for their continuance, or for a grade separation, which would not be the case if there was better co-operation in locating the roads between these independent highway authorities and with mandatory authority lodged at some central source.

Grade separations are frequently compelled at such crossings because utility commissions, in many States, have no legal authority to close such highways, or compel suitable relocation, although aware that the public interest as a whole does not demand either the grade crossing or the separation. Utility commissions are usually unwilling to assume responsibility of continuing a crossing at grade, when its hazardous condition has been officially called to their attention, and are also not inclined to assume responsibility for modern forms of highway protection. As they have no jurisdiction over the Federal, State or country highway authorities, a separation of grades on the unnecessary road is usually the easiest way out irrespective of the economic or financial problem involved; although it should be said in justice to some of the state utility commissions that this is not always the case.

Highway legislation in most states needs a thoroughgoing renovation to put it in step with modern conditions, a fact well known to most highway engineering authorities.

The Federal Government and the States have already paid more than $994,000,000 for the construction of about 50,000 miles of Federal-State highways, and in the interest of the railways and the highways, as well as in the interests of public safety and public expenditures, the excess highway grade crossings thus rendered unnecessary should now be closed.

Remove Hazardous Crossings

This action should be immediately followed up by the removal of the extra-hazardous grade crossings which now exist on every railway and are alike dangerous to the public, the highways and the railways.

In the interest of public safety some way should be found by state public utility commissions, through suitable legislation, if necessary, whereby state highway commissions will be required to give first preferred attention to such crossings, even though it reverses present policies of Federal-State highway construction.

If plans of this character were carried out it would reduce the total number of existing grade crossings in the United States from approximately 250,000 to about 75,000, of which only 10,000 are on the main trunk or Federal-State thoroughfares. It would save a vast army of human lives each year and reduce an appalling list of casualties as well as result in the saving of staggering sums now being expended by the public through the agency of the railways and the highways for the maintenance of unnecessary grade crossings.

The present planning of Federal-State highway roads in practically every State bears absolutely no relation to these hazardous crossings, and railway funds otherwise available for aid in grade crossing elimination are thus diverted by the action of state highway commissions to crossings which bear little or no relation to the existing extra-hazardous crossings.

The Federal-State highway system is being planned and developed without proper co-ordination with the railway system, and as the laws under which the Federal and State highway commissions are organized do not require state highway commissions to be conversant with requirements in steam railway transport, it is not altogether surprising that with all of the money being paid out for grade crossing elimination, there still continues to be a heavy loss of life and unnecessary accidents at extra-hazardous grade crossings which would otherwise have been given preference by railways in elimination programs.

Uniformity of Protection Needed

There is also urgent need for agreement between public authorities and the transport system for uniformity in the protection of the less hazardous grade crossings and intersections. These crossings constitute by far the greatest percentage of the total grade crossings and have the greatest potential hazard for the public. A proper understanding of this problem is of first importance, to be followed up by scientific treatment along modern lines and consistent with public safety requirements.

It is easily the greatest menace and correspondingly the greatest safety measure before the public, yet, strange to say, it is little understood by many public authorities in the light of modern necessities. Highway bodies and commissions often fail to appreciate why manually operated protection is now so frequently found insufficient and unsafe to cope with modern conditions. Automatic forms (known as automatic flagmen) requiring compulsory contributary action by the highway user with a uniformity of

types and use, are recognized by experts as being the best and surest means of public education.

It would seem that the accomplishment of this objective is so essentially in the public interest that its importance need not be further dwelt upon, but until the railways can deal with a national public authority with sufficient jurisdiction, this menace seems destined to continue.

Number of Crossings Increases

Highway legislation of former days is not in step with modern conditions of transport necessities, with the result that while vast sums of money are being expended annually for grade crossing elimination, yet the number of grade crossings continues to increase each year by official sanction irrespective of the almost criminal hazard and liability thus created.

Some eastern states do not permit their public authorities to create additional grade crossings. In states where this is in effect for a number of years, it has been found to bring about excellent results.

With a properly articulated system of trunk and feeder roads, very few additional crossings are necessary. If such crossings were required to be separated in the first instance and the costs apportioned by assessment against the property and interests benefited, there would be a reasonable decrease in this agitation. Meanwhile State public utility commissions and other similar authorities would be relieved from the necessity of either creating the hazard or offending their constituents.

Vehicle Operators Are Not Under Control

The self-propelled machines operating on the railways and on the highways are now equivalent in capacity for speed, and necessarily require the same character of systematic skilled examination, supervision, and control. The railways provide this. Their enginemen who operate the locomotives are advanced to that position only after long years of training and experience and always thereafter with continuing checks on eyesight, discipline, habits and mental alertness. These men have behind them established records for carefulness and with reputations for safe operation to maintain. They are in turn supported by a staff of mechanical experts and supervisors with facilities for thoroughgoing examinations of their machines after every trip, and backed up by stringent national safety appliance laws with Federal inspectors to see that they are enforced. No such provision can be made by National, State, county or municipal highway authorities because of divided responsibility, divergence of views, and defective legislation. It is only through public education that there will come laws and regulations which will compel modern legislation to replace the ancient moss-grown statutes of the horse-drawn-vehicle age with modern devices replacing present practices so that comparable safe operation will be possible.

Roads Built With Public Funds

The Federal-State trunk highway system now completed comprises 53,958 miles. The program for extension contemplates its development into 70,752

miles, and when finally completed 200,347 miles, with future possibilities for development under the existing law. These highways are being built parallel to and across the railway system whenever in the opinion of the state highway authorities it appears desirable. Many of these crossings are new and in addition to what formerly existed. In some cases the released crossings are closed, but as heretofore pointed out the net result is to increase rather than decrease the number of highway grade crossings.

Under the provisions of the Federal law, to which reference has been previously made, the government has already expended $439,339,402 to aid in the construction of the Federal-State highway system, and the State taxpayers have expended $555,340,454.

Since 1916 the Government of the United States has entered upon a program of aiding in the construction of the principal trunk line mileage constituting national or Federal-State highway systems.

The first highway act of Congress approved July 11, 1916, under the title, "an Act to provide that the United States shall aid the States in construction of rural post roads" (39 Stat. 355). In the first section it is provided:

> "That the Secretary of Agriculture is authorized to co-operate with the States through their respective State Highway Departments in the construction of rural post roads; but no money apportioned under this Act shall be expended until the Legislature shall have assented to the provisions of this Act . . ."

The passage of this law resulted in the creation of the Federal Bureau of Roads and the organization of State Highway Commissions in the several states. These were charged with the duty of building the Federal-State highways in conformity with the provisions of the act.

Give Bureau of Public Roads More Power

The functions of the Bureau of Public Roads are limited by this act and largely devoted to the apportionment of Federal appropriations to the States in the manner prescribed by law. Unfortunately the Bureau does not have sufficient or proper authority under this law to regulate standard practices. Beyond this their functions are largely of an advisory and administrative character.

The Bureau is admirably organized and administered. It is composed of well-trained engineers qualified in the science and art of highway construction and it is unfortunate for the general public that the law does not give them sufficient power or authority to insist upon uniform standards for construction and maintenance. In the interest of public safety and convenience, the power and authority of this Bureau should be enlarged along lines similar to the Engineering Corps of the United States Army. It should be taken from the Department of Agriculture, where it does not belong, and placed under the Interstate Commerce Commission or under the Department of Commerce, depending upon how the organization is affected.

While the State laws creating the highway commissions of the several States differ materially, their principal function is substantially the con-

struction and maintenance of the Federal-State highway system, which, as stated, constitutes a very small part of the State highways. They have little or no jurisdiction over the remaining State highways. They are largely political in character but fortunately, through provisions of Federal requirement, the expenditures are made through a competent body of State engineers well qualified for their duties, and their jurisdiction should be extended over the highways in their respective states with respect to construction, maintenance, highway marking, and standard practices, also working in close alliance with the Federal Bureau of Public Roads.

Place State Roads Under Public Utility Commission

As the Federal and State laws of all the states now vest control of the principal transport agencies in their respective public utility commissions, it is difficult to see why a duplicating body in the shape of a State highway commission with independent authority should also exist. Simplicity of administration and public safety would be greatly advanced if the commissions were abolished and the administrative functions performed under the State public utility commission to which the state bureau of highway engineering might well report. A change of this character would be an outstanding advantage in the advance in the administration of the public highway system. For the same reason it follows that the jurisdiction of the public utility commissions should also be extended over county, township and municipal roads, in so far as they affect safe and convenient public operation, and placing the control of railway grade crossing and highway intersections solely within their jurisdiction, similar to the Illinois law which places the control of all grade crossings in the State within the jurisdiction of its Commerce (Public Utility) Commission. This arrangement would permit utility commissions to extend the jurisdiction of their expert transportation staffs (now functioning for railway or water transport) so as to include intrastate highway and waterway transport as well.

Division of Cost Is Difficult Matter

The greatest stumbling block in the way of an orderly program for the elimination and protection of unnecessary highway grade crossings is the lack of common understanding on the part of the parties immediately concerned regarding the apportionment of cost for the changes. It may be said at once that there is little doubt but that the railways would look with favor upon some systematic and orderly program of grade crossing elimination if the costs were equitably apportioned with due consideration to existing extra-hazardous crossings and the closing of unnecessary crossings, recognizing meanwhile that a proper development in the highway system may frequently mean the crossing of the railways at points where no crossing at present exists, or the occasional selection of a crossing which at the time may not be one of the particularly burdensome crossings in the affected area. All these problems are susceptible of solution in the interests of the general public when there is a better understanding on the part of all concerned, of the economic and safety aspects of the grade crossing problem.

The Federal Bureau of Public Roads has outlined some admirable provisions with respect to grade separation. It considers that while ultimate elimination is the final solution, it is, after all, an economic and financial problem, in which the more dangerous crossings on the Federal-State highway system should be first considered, and apparently recognizes in principle the fact that there are many extra-hazardous crossings on the several railways which are not on the Federal-aid thoroughfares, concerning which the railways must deal with State, county, municipal or other public bodies, and to which railway funds must also be allocated, but as the Bureau is concerned, under the law, with aiding in the construction of what is in effect the national highway system, the Government is directly interested in the elimination of the more dangerous crossings created thereby.

Federal law has clearly anticipated this in Section 2 of the Act of Congress previously mentioned, and provides, among other things:

> "That for the purpose of this Act the term 'rural post road' shall be construed to mean any public road over which the United States mails now are or may hereafter be transported excluding every street and road in a place having a population, as shown by the latest available Federal census, of two thousand five hundred or more, except that portion of any such street or road along which the houses average more than two hundred feet apart; . . . necessary bridges and culverts shall be deemed parts of the respective roads covered by the provisions of this Act."

In making appropriations for the Post Office Department for the fiscal year ending June 30, 1923, and for other purposes, Congress further provided:

> "For the purposes of this section and of the acts heretofore making appropriations to aid the States in the construction of rural post roads the term 'bridges' includes railway grade separations, whether by means of overhead or underpass crossings." (42 Stat. 660).

Also by Section 8 in Regulation 6 of the "Rules and Regulations of the Secretary of Agriculture for Carrying Out the Federal Railway Act," it is stated:

> "Grade crossings occurring on the Federal Aid Highway System shall be classified for priority of improvement by agreement between the State Highway Departments and the Bureau of Public Roads."

It will be seen from the foregoing that it is clearly the purpose of Congress to aid in the elimination of the grade crossing hazard which the construction of the Federal Aid System of roads must necessarily encourage. The Federal Act was originally passed as a rider to the Agricultural Bill and shows evidence of being somewhat hastily drawn and in the light of its practical application is loosely worded and susceptible of various interpretations. This fact has permitted a number of State highway commissions to nullify the clear intent of Congress and apply the Federal funds that should otherwise be spent on grade separations for the construction of additional highways elsewhere in the State and by taking advantage of State laws passed during the horse-drawn-vehicle age they seek to compel the railways to assume a far greater portion of the expense than can be reasonably justified. This is not surprising because, as previously stated,

state highway commissions have no responsible connection with the public for providing necessary safe and convenient railway transport.

The railways on the other hand believe that there is no difference in principle between withholding the Federal aid from a Federal-State highway grade separation project, so that the money might be expended elsewhere in the construction of roads, thereby exacting from the railways that amount of money which would be equivalent to Federal aid, and taking the railways' moneys for constructing highways elsewhere in the State.

Railways Must Deal with Many Local Bodies

Meanwhile, the railways are called upon to deal with other highway bodies in cities on their problems of grade separation or track elevation, and again with county and other bodies on crossing eliminations over which neither the municipal nor the State highway commission has jurisdiction each applying different reasonings and formulas, and none of them directly concerned with its effect on public transport service by the railways. It is not surprising, therefore, that controversy results and essential grade separations are unduly delayed, and often unsatisfactorily executed in the interests of the public when finally undertaken.

Arbitrary Assessment of Cost Is Wrong

It is a well-developed principle of economics and in harmony with sound business methods that apportionments of cost for public improvements of this and like character should be apportioned on the basis of the benefits received, but it is very difficult in some States to get State highway commissions or other highway authorities to concur in this principle. A railway is benefited by a separation of grade wherever its presence enhances the danger of a grade crossing to the extent and degree of danger which its presence creates, and no more. In other words, an arbitrary assessment irrespective of the benefits received is wrong in principle and contrary to the spirit of the common law. Federal and State laws relating to appropriations for highway construction should be so amended as to require a fixed portion to be available only for grade separation projects. By so doing it would remove the apparently irresistible temptation from state highway authorities to please their constituents by construction of additional highways while leaving the general public to be injured and killed at hazardous or extra-hazardous grade crossings which otherwise might be abolished. Until some action of this kind is written into the statutes, public safety at railway crossings must remain largely a matter of policing by the railways with such assistance from local communities as their officers may, for the time being, persuade them to give, until the state highway commissions, in the state where such ruling prevails, can be brought to realize that grade crossing elimination will be greatly accelerated on the Federal-State highways, and public safety and convenience enormously advanced by enlisting co-operation with all the affected interests in such a way that the apportionment of costs will be equitably spread. Also that this is much more to be desired than the building of a few more highways.

The same principle, of course, applies in the apportionment of cost to the protection of a vast number of hazardous and other crossings where

highway protection is necessary. Changed conditions of public travel require that where the hazard is sufficiently great the public will be protected and that the costs should be apportioned on the basis of the benefits received alike to the user of the highway and the user of the railway and other political subdivisions or interests benefited so far as their interests can be shown. An application of this principle would permit better and safer protection than is now possible when public authorities undertake to saddle the expense on a single interest and divert the tax funds collected for safe and proper maintenance to other purposes.

General Plan Would Avoid Unnecessary Separations

State utility commissions have concurrent jurisdiction with the Interstate Commerce Commission over the railways in their respective states but they have no jurisdiction over State highway commissions who are the nearest approach in the several States to controlling the highways of their states. Although the utility commissions may give or withhold the authority for the creation of additional grade crossings, they have no authority to alter, amend or change programs of the State highway commissions with respect to this as pertains to highways or highway crossings, even though by so doing the railways or public interests may require such alterations, amendments or changes. As a result, the railways are frequently called upon to appropriate funds for the elimination of grade crossings which later may be rendered unnecessary and would be avoided if some central authority interested in the railway and the highways were in a position to enforce a plan of highway construction. The same thing applies with equal or greater force to the lesser political divisions in the shape of county roads.

National Problem Based on Benefits

It will be seen from the foregoing that highway grade crossing protection for elimination is a national question and that the public is interested through its control of the railways on the one hand and the highways on the other hand. Also that the Federal Government is equally interested because of its control over interstate transportation. Various other agencies are equally interested, for example, the bus or truck lines operating for hire, or other interests including the railways as the facts may develop.

The apportionment of cost should be on the basis of benefits received, both with respect to elimination and crossing protection, with standard practices adopted which will represent the best and most economical forms of construction and maintenance throughout.

If this is worked out with proper legislation incident thereto, it will result in the development of a plan for the elimination of dangerous crossings, meanwhile protecting the remaining highways of lesser importance by standard marking so that the public will become accustomed to them, which will result in the lessening of the daily loss of life and the unnecessary costs incident thereto, meanwhile permitting both transportation systems better to understand the workings of one another and their relations with the public, a fact which is impossible under the present conditions.

COMMITTEE ON BOILER FEED WATER STUDIES

FOREWORD

By C. R. Knowles, Chairman Water Service Committee.

A study of the various processes employed in the purification of feed water for locomotives and stationary steam power plants is being carried on by this committee in co-operation with five national technical organizations, including the American Railway Engineering Association.

The object of the research work is to determine the fundamental principles underlying certain phenomena which take place in steam boilers. The committee is sponsored by the American Railway Engineering Association, the American Water Works Association, the National Electric Light Association, the American Society for Testing Materials and the American Society of Mechanical Engineers. The work has been divided between nine sub-committees and an advisory committee.

Ten reports of the committee presented at the meeting of the American Society of Mechanical Engineers, December, 1926, and five papers originated by this committee and read at the meeting of the American Water Works Association in Chicago on June 26th are included in this Bulletin, and are presented under the direction of Committee XIII—Water Service.

WATER TREATMENT FROM THE STANDPOINT OF RAILROAD EFFICIENCY

E. M. Grime, Engineer Water Service, Northern Pacific Railway

It is a well-known fact that the efficiency of American railways has been increased to a remarkable extent during the past ten or fifteen years. This has not been brought about in any great measure by the construction of additional lines to open up new territory, but rather by large expenditures to improve existing facilities so as to give better service at less cost. Every feature of railway operation has been scrutinized and changes made wherever a saving could be shown either in time or operating costs. Not the least of the savings accomplished in this manner has been the lengthening out of locomotive runs. Where it was formerly the custom to operate over a one-hundred and one-hundred-and-fifty-mile district and then put the locomotive into a house where it was inspected, cleaned, and repaired if necessary, now it is run two hundred, five hundred, or in some cases as far as nine hundred miles at a stretch requiring little more attention than was formerly considered necessary for the shorter runs.

In those cases where the water supply is of very poor quality the accumulation of scale and the concentration of soluble salts may still make it desirable to wash the boiler at the end of a two hundred-mile run, but the longer runs are now successfully made in naturally good water territory and also equally well in those districts where through the skill of the engineer and the chemist very poor waters have been treated in such a way as to make them practically equal to the best of natural waters. On railways where bad water conditions still exist it has been stated that the correction of this condition promises a larger return on the required capital investment than any other improvement that now remains to be made.

The development of railway water supply facilities has been gradual and naturally followed the increases of traffic. In early days when locomotives were small, a wayside tank holding about seven thousand gallons was ample and the most primitive methods of pumping answered the purpose, whereas today highly efficient pumping plants, one hundred thousand-gallon storage tanks, and water columns delivering a flow of three thousand to five thousand gallons per minute are demanded as a necessity to serve the modern locomotive. Each minute of time that can be saved has a definite value, and on eastern lines of dense traffic the rather costly open water trackpan which permits the filling of tenders without even a stop is justified. In early days the quality of the water received little attention and most anything that was wet answered the purpose, but it was not long before certain waters were found to cause serious trouble by foaming and also to fill up the water spaces with a hard scale which it became increasingly difficult to remove. Various substances known as boiler compounds were tried in an effort to overcome this trouble, but as the natural waters in a given district invariably differ in quality what may be a help with one is not satisfactory

for another water, and so little was gained by this method of internal boiler water treatment. European railways were the first to investigate methods for improving poor boiler water, but not much was accomplished until in 1841, Clark of Scotland successfully used lime to precipitate the carbonates of lime and magnesium and a few years later, Porter, an Englishman, suggested the use of soda ash to decompose the lime and magnesium sulphates. A combination of these two methods for treatment of the water before it entered the boiler was soon worked out and on account of the simplicity of the process and the comparatively low cost of the chemicals involved this method has become the basis for most water softening processes as used on railways.

The desirability of using properly softened water for locomotives became more apparent as railway traffic increased, larger locomotives were put into service and the working conditions became more severe. In aggravated cases locomotive boiler tubes would last only six months and the dropping of crown sheets due to overheating by reason of the insulating effect of heavy scale deposits was not uncommon. Leaky flues would necessitate the attention of boiler makers after every trip, and a combination of these troubles with foaming due to concentrated alkali salts contributed to serious operating difficulties.

Experiments with the use of water softened by the lime-soda process indicated that the life of tubes could be considerably increased and boiler repairs materially reduced. This gave quite an impetus to the adoption of methods for treating the water at those locations where it was not possible to find a suitable natural soft water, and it is now recognized that to secure efficient results all the water on a given engine district should be softened in order to secure approximately uniform quality. In 1904 the Water Service Committee of the American Railway Engineering Association reported that 27 railways had been found to have installed water treating plants and in 1905 15 others were following the same course, and there was no longer any question as to the beneficial results being accomplished. It was found that as the water was improved, boiler-maker forces could be gradually decreased and that the savings to be accomplished were worth while not only on this account but also by reason of the shorter time the locomotive was held out of service and the very large improvement in train operation.

Some of the savings accomplished were found difficult to capitalize, but it seemed desirable to arrive at definite data by which to measure the losses due to the use of bad water and the capital expenditure that would be justified to purify a given supply. The Water Service Committee referred to made a careful analysis of these losses in 1914 and came to the conclusion that the damage caused by the accumulation in a locomotive boiler of one pound of scale-forming material amounted to seven cents. Since that time, on account of the increased cost of everything that enters into the calculation, it has been found proper to increase this figure to thirteen cents. Stated in other terms, each grain of hardness in a bad water does a damage of

$.0186 per one thousand gallons of water evaporated. It is realized that a hard sulphate scale will be more injurious than the same thickness of soft carbonate scale, but usually there is a mixture of the two in varying quantities. At the same time there are other elements to be taken into account besides simply the insulating effects due to the scale, and this figure is therefore taken as an average value sufficiently accurate for practical purposes. That this is very conservative is shown by the fact that the actual losses as determined by the cost of locomotive maintenance in a bad-water territory compared with costs in a good-water territory show up much higher than may be determined by the thirteen-cent figure. On a leading Eastern railway, where the water quality can hardly be considered as being in the very poor class, a careful study of boiler maintenance and fuel costs shows that the annual loss due to bad water on its lines amounts to over $3,000,000 and that in every case the actual loss exceeds what would be indicated by the use of this A.R.E.A. rule. With this as a basis it is not uncommon to find that the annual savings to be anticipated by reason of boiler feed water treatment are annually 25 to 50 per cent of the total amount of the capital expenditure required for construction of water treating facilities. If doubt should still exist as to the correctness of evaluating scale accumulation damage in this manner on a railway which has both good and bad-water territory, a study of the statistics showing the cost of locomotive maintenance per mile may fairly indicate some measure of the damage done by bad water. All other conditions, such as type of locomotive, ruling grades, tonnage, and other operating details being substantially the same, a cost for locomotive maintenance in a certain district regularly exceeding the average cost for this item will show to what extent bad water is interfering with efficient operation. A comparison recently made in this way showed an excess locomotive maintenance cost on a bad-water division of $215,000 per annum compared with an annual loss of $105,000 computed on the thirteen-cent basis. The improvements suggested as necessary to eliminate this $105,000 are estimated to cost $362,000, and the correction of this condition will therefore show a saving of 29 per cent on the investment.

As a rule the damage done by reason of the accumulation of scale is most apparent in the necessity for washing of boilers at short intervals, of excessive repairs to tubes, flues, and fire-boxes, and in fuel losses; but on most Western railways, aside from these difficulties, we have a serious problem in the matter of pitting and corrosion which causes the scrapping of tubes and sheets in but a fraction of what should be their useful life. Some have held that a coating of scale seems to be a protection against corrosion, but in most cases when sulphates of the alkali metal group are present as well as alkali sulphates and the water is thus a good electrolyte, corrosion takes places regardless of the scale. Pits will develop underneath the hardest kind of scale coating and will eventually pierce the metal, causing failure of the tube. Where some kind of internal boiler water treatment is resorted to, causing partial removal of the scale, the pits may be scattered over a wider area and not penetrate the tube quite so quickly.

It is now usually conceded that this pitting is due to electrolytic action made possible because the boiler water is a good medium for the passage of minute electric currents between points of differing potential on the surface of the metal. The metal of the tube or shell is dissolved at the anode while hydrogen is plated out at the cathode. F. N. Speller has observed that the smaller the anodic areas with relation to the cathodic, the greater will be the rate of corrosion at the anodic points and therefore the greater tendency to form small holes or pits. This apparently explains the early pitting through of the tube where scale is dense or mostly of the hard sulphate kind as compared with more uniform corrosion but slower complete penetration where scale is of the soft carbonate variety. The Water Service Committee of the American Railway Engineering Association after conducting extensive tests arrived at the conclusion that waters which are good electrolytes can be deprived of this quality by adding in the treating process sufficient excess lime and soda to create a sodium hydrate alkalinity. The rule is

$$\frac{\text{Grains sodium sulphate plus grains sodium chloride}}{10} \text{ plus } X$$

equals the grains sodium hydrate necessary to inhibit corrosion. X is a variable covering constituents in the water other than sodium sulphate and sodium chloride. For distilled water X becomes 5, but in the presence of carbonates or hydrates of calcium and magnesium it can probably be disregarded.

In the arid regions of the West many deep well waters are found which contain a large amount of alkali sulphate but fortunately they frequently also contain sodium carbonate and evidently the latter, under boiler conditions, forms sufficient caustic to act as an inhibitor. It is not unusual to find stationary boilers using such water that have been in service for fifteen to thirty years with practically no corrosion trouble. If any incrustation is seen, it is around hand hole plates where a slight amount of leakage and evaporation has left a rim of caustic soda crystals. A prominent railway is now utilizing these natural deep well alkali sulphate and carbonate waters over an entire engine district, and so far the reports indicate large savings in boiler maintenance costs with no serious foaming troubles and no corrosion.

It seems evident that corrosion in a locomotive boiler will not continue unless oxygen is present in the water to take up the hydrogen which collects on the cathodic areas and which would otherwise, by its polarizing effect, tend to stop the flow of current. It therefore seems most desirable to eliminate from the feed water as much as possible of the uncombined oxygen. Working on this theory, the open feed water heater which gives the oxygen a chance to escape before the water enters the boiler should materially improve conditions. Experiments to determine this are now in progress on several railways and where conditions are such that heaters of this type can be used exclusively and kept in proper working order so far they appear to accomplish definite results in the way of decreasing corrosion.

As yet it cannot be said that the experiments are conclusive, but this method of increasing locomotive efficiency will be watched with interest.

This polarizing effect of hydrogen which tends to stop the passage of the electric current has been utilized by Mr. Gunderson in some interesting experiments on the Chicago & Alton Railway. By means of two electrodes (anodes) introduced into the boiler below the water line, one at the upper right and the other at the lower left side, extending nearly the full length and perfectly insulated from the boiler shell, a positive charge of electricity amounting to ten amperes for each electrode is taken from the headlight generator and is passed through the water (the electrolyte) into the tubes and boiler shell, thus making every part that might be subject to corrosion cathodic instead of anodic. In addition to this counter electric current, and in order to further prevent the passage of a minute current from one point on the metal to an adjacent point, a so-called secondary cathode is created by adding to the boiler water once every thirty days one pound of sodium arsenate which immediately plates out on the boiler shell and tubes, and by reason of its high discharge potential for hydrogen, assists in holding the hydrogen film which would otherwise be more readily removed by combination with any free oxygen present in the boiler water. Boilers in which this method has been used are almost entirely free from corrosion whereas others in the same territory and under similar working conditions have a very brief tube life. For waters where scaling conditions are not serious or where soda ash treatment alone will hold down scale accumulation to the minimum, this counter electrical method promises a large increase in locomotive efficiency.

There are so many factors entering into the treatment of boiler feed water for railway uses that the problem actually becomes somewhat complex and requires careful study in order to select for given conditions the best method of treatment to secure the greatest measure of efficiency. The lime-soda treatment for waters high in the sulphates of lime and magnesium tends to increase the so-called foaming salts and thereby, above certain limits, to add to the difficulties of operation. In his efforts to provide a water free from harmful physical effects and thereby reduce the cost per mile of locomotive maintenance the water engineer therefore faces the objections of some operating men who fear the slightest foaming trouble which may contribute to traffic delays. We are not certain as to the exact cause of foaming, but it can be shown that large concentration of sodium salts will not cause foaming if there is no insoluble or colloidal material present in suspension. Evidently it takes a combination of the above to cause foaming and the density of the dissolved salts as well as the character of the suspended matter also has some bearing. In any event this matter presents difficulties that require constant attention. When treatment is first started and the boilers have not yet become thoroughly freed of scale, in order to have smooth operating conditions, a limited amount of some good anti-foam compound may be found desirable. The basis of these anti-foam compounds is castor oil and experiments have shown that one pint

of this substance to five thousand gallons of boiler water will hold down a raw water containing as high as 125 grains per gallon of sodium sulphate and twenty grains of insoluble precipitates. Its careful use with a well treated water should therefore solve any foaming troubles. As a rule after water treatment has been in use for a time, if all waters in an operating district are properly softened, the enginemen find they can get along without the compound. The period required to attain this condition will depend on how long it takes to get the boilers thoroughly clean so there is no longer finely divided insoluble material remaining to aggravate foaming. Under these conditions a moderate amount of blowing down combined with the moderate use of anti-foam compound constitute the ideal operation for greatest efficiency. While the water engineer is interested in a water perfect as far as corrosion and non-scaling qualities are concerned, he cannot lose sight of the fact that the railroad is operated primarily to move traffic and everything else must be secondary to having trains move without delay. Foaming conditions which cannot be controlled with reasonable precautions must therefore be avoided by securing a better water supply even though this may involve considerable expense.

A discussion of increased efficiency by reason of boiler feed water treatment would not be complete without mention of the zeolite method of water softening. Zeolite mineral or green sand is a base exchange silicate which has been successfully used for water softening in the industries for a number of years and is now being tried out for railroad use on the Pacific Coast where water conditions are suitable and common salt can be purchased at a favorable price. This mineral can be made synthetically but is now usually secured from one of several natural deposits in this country and put through a cleaning and grading process to make it suitable for an efficient filter. The raw water is passed through a filter bed composed of zeolite mineral at a predetermined rate, depending on the softening capacity of the zeolite sand, and the carbonates and sulphates of calcium and magnesium are thereby exchanged for carbonates and sulphates of sodium, leaving the water of one grain or less in hardness. When the capacity of the zeolite has been exhausted, the filter is back-washed to loosen the bed, a solution of common salt is passed through to restore the sodium base, and then after washing with fresh water, the filter is again ready for the softening process. Approximately one-half pound of salt is required for regeneration of the mineral per one thousand grains of hardness removed from the raw water. For successful operation it is essential that the raw water be almost entirely free from turbidity as any matter in suspension will tend to coat the zeolite grains and clog the filter. The raw water should also be practically free from acid, iron, alumina, and manganese. The increase in sodium salts by this method makes it desirable to have a raw water low in sodium chloride or sulphate and the less calcium or magnesium bicarbonate, the better. While the lime-soda process removes the calcium and magnesium carbonates, the zeolite simply changes them to sodium carbonates. Zeolite treatment thus increases the soluble solids over ordinary lime-soda treat-

ment, but this is about offset by the excess treatment often required in the lime-soda process in order to secure complete softening and a caustic quality sufficient to inhibit corrosion. While it has not yet been definitely proven, it seems probable that the sodium carbonate produced by the removal of carbonate hardness will, under boiler conditions, change to caustic at a sufficiently rapid rate to inhibit the corrosive tendencies of any sodium sulphate which may be present. For most places in the interior of the country the price of salt is such that for the removal of carbonates lime is a cheaper chemical than salt while for the removal of sulphates salt is a cheaper chemical than soda ash. For some situations a combination of lime treatment to first remove part of the carbonates and the zeolite to change the sulphates will work out to advantage. After-precipitation in long pipe lines is sometimes a problem with lime-soda softeners and this trouble is not present with zeolite treatment. Zeolite by-products are soluble, making this type of treatment often advantageous where the disposal of sludge from a lime-soda plant would be a serious problem. The operation of a zeolite plant is simple and it does not require that close technical attention necessary for regulation of a lime-soda plant.

One of the principal advantages of the base exchange method is the reduction of hardness to one grain or less, a result difficult to secure by the lime-soda process without using a considerable excess of reagents. It is therefore worthy of mention that where the lime-soda process is in use, by the addition of sodium aluminate the hardness in many cases is being brought down as low as one grain, giving a treated water which in respect to total solids may be superior to water treated by the zeolite method. Sodium aluminate by an improved process is now being manufactured in the dry form, making it very convenient for handling, and its use is now adding materially to the efficient operation of many water treating plants. When added during the treating process it forms a heavy floc which as it settles has a filtering effect that entangles or drags down the finer particles of precipitate formed by the chemical reactions and gives a perfectly clear water in minimum settling time. During cold weather especially, certain waters, which will not settle out clear for an indefinite period and still remain three or four grains hard, when thoroughly agitated with sodium aluminate solution will clarify in thirty minutes or less and drop to a hardness between one and two grains. The claim is made that by the use of this material the excess treatment with lime and soda, often necessary to bring down the hardness of certain waters, can be avoided to a large extent. This can only be proven by actual tests with each kind of water.

It may be said that a locomotive is only as good as its boiler. As long as steam remains the chief source of power for railroad operation, the conditions of the boiler will be a prime factor in operating efficiency. The increasing competition from motor busses and waterways makes the need urgent for more powerful and efficient locomotives. With locomotives approaching what would appear to be their maximum size, the nearest development within reach is along the line of higher steam pressure. Increasing the rate of

evaporation increases the rate of concentration of any impurities which may exist in the boiler water, as well as the scale accumulation. The corrosion tendencies then become more active and it is evident that higher efficiency for the locomotive adds greatly to the necessity for securing perfectly pure water. This is in line with the tendency in stationary plant practice where water approaching zero hardness is now commonly demanded.

Water treatment is essentially an engineering problem. In order to produce the best results and increase the efficiency of the railway, each plant should be carefully considered with reference to its proper location for the best train operation, the availability and quality of the raw water supply as affecting treating costs, and the type of water treating facilities best adapted to satisfy all conditions.

THE VALUE OF BOILER WATER TREATMENT TO THE MECHANICAL DEPARTMENT

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The paramount issue with the Transportation Department of any railroad is essentially the efficient and economical movement of traffic, causing ever-increasing demands on the Mechanical Department for motive power capable of handling heavier tonnage at increased speed, resulting in constructing larger and heavier locomotives with higher steam pressure.

The boiler has been designed to accommodate and serve this increased power, the firebox has been made larger, but in a great many instances no provisions have been made to increase the circulation at the forward end of the boiler. This contributes to the sluggish movement and concentration of those agents in the water which lead to pitting and corrosion and is responsible for the trouble experienced from the flues pitting and corroding just inside of the front flue sheet.

There is no other type of steam generator that compares with the locomotive boiler in its intermittent duty and capacity range while in service, which ordinarily is only for a few hours of the twenty-four. The balance of the time it is subjected to destructive stresses due to standing idle, cooling down, washout and firing up and these stresses are greatly augmented by the scale adhering on the plates, staybolts and flues, which has a tendency to cause these parts to become fatigued due to overheating, resulting in cracked plates, broken and leaky staybolts and leaky flues.

The necessity of developing the maximum efficiency from the motive power at hand has resulted in the co-operation and co-ordination of railway officials, in both the Mechanical and Transportation Departments. It is becoming generally recognized that an adequate supply of water suitable for use in locomotive boilers is the first essential towards obtaining greater locomotive efficiency.

The cost of boiler feed water does not end however with its delivery to the locomotive tender, as boiler troubles and the majority of their repairs and renewals are traceable to the water supply. Therefore it is essential to secure suitable water even though the initial cost may seem prohibitive and entirely out of proportion to the actual cost of water requiring treatment obtained from another source, and where it is not possible to secure a good or fair grade of water, arrangements should be made to employ some effective means for purification to prevent scale formation and corrosion within the boiler.

Impurities in the water are in the nature of mineral salts, mud, vegetable matter and gas, and are contained in all waters in varying amounts and proportions, the mineral salts in sufficient quantity and suspended matter form a more or less coherent scale on the flues, firebox sheets and interior of the boiler.

The principal scale-forming impurities are carbonates and sulphates of lime and magnesium. Calcium sulphate is responsible for the forma-

tion of the hardest kind of scale and is the most detrimental to the firebox sheets and flues, causing the flues to leak and the beads to burn off, the staybolts to leak and the side sheets to crack around staybolt holes, necessitating the renewal of the flues and side sheets after about 14 to 18 months' service.

The incrusting solids contained in boiler feed water, while contributing largely to the maintenance cost and the decreased efficiency of the locomotive, are not the most detrimental ingredients encountered. Waters containing calcium chloride, magnesium chloride or sulphate, sodium chloride or sulphates or nitrates, cause a pitting and corrosive action which is exceedingly dangerous and expensive.

Locomotives operating in territories where the feed waters are impregnated with incrusting solids, require frequent washing of the boiler and increased maintenance expense, such as the renewal of staybolts in the fire line and flues. The latter can be cleaned, safe ended and replaced, the interior of the shell scaled and the firebox sheets can be vibrated at regular intervals and their life very materially prolonged. This, however, does not apply to locomotives receiving highly corrosive waters, which attacks the flues, firebox and shell plates. In some instances holes will develop in the flues after about eight months' service and firebox sheets will become dangerous and require renewing after two to three years' service. These waters will also attack the boiler shell making it necessary to renew the lower portion of the shell, back head, throat sheet and casing sheets.

While corrosive waters are not as prevalent as those causing heavy incrustation, they are more detrimental and more expensive to the railway, as it is necessary to scrap from 25 per cent to the entire set of flues removed from some locomotive boilers.

The ordinary Mikado type locomotive has 262 two-inch and 36 5⅜-inch flues, which can be removed, cleaned, safe ended and reset for $0.75 each for the two-inch and $2.25 each for the 5⅜-inch flues, or a total cost of $277.50, as compared to a total cost of $1,274.25 when it becomes necessary to scrap the entire set due to pitting. This comparison is also true only to a greater degree with respect to the renewal of boiler and firebox sheets.

Improving the quality of boiler feed water is one of the most vital factors to be considered by railway officials, as it directly or indirectly affects every department on the railway. The Maintenance of Way Department is concerned chiefly with the cost of supplying the water, the Operating Department are deeply interested because they use it and the Mechanical Department is vitally interested, first, in reducing maintenance cost and maintaining the locomotive in service for a longer period between shopping; second, in providing free steaming locomotives, free from leaks and capable of performing the hardest kind of service, without danger of a boiler failure.

The economics of water purification are far-reaching, making it difficult to determine the value of indirect benefits, such as decreased boiler failures, improved locomotive performance, less time out of service, better steaming engines, fewer delays to traffic and lower maintenance cost. Even

the savings effected by the increased life of flues and firebox sheets, reduction in broken staybolts, reduction in boiler washouts and less boiler repairs, are hard to determine due to the transfer of motive power. In some instances the entire assignment of locomotives have been changed since the installation of the treating plants.

Prior to the treatment of the water it was necessary to remove the flues after 25,000 to 30,000 miles; the firebox sheets were vibrated every thirty days and the rear flue sheet and slide sheets were renewed at each general repairs. Since the installation of the treating plants we have discontinued vibrating the firebox sheets, the flues are averaging 120,000 miles between resetting and the locomotives are being turned out of the shop without the renewal of firebox sheets, although the locomotives are larger and evaporate a great deal more water than those formerly used in the treated water district.

The railway with which I am connected has in service 36 treating plants located at points where the raw waters contain from 8.3 to 35.3 grains of incrusting solids per gallon. At other points where the consumption of water is not sufficient to justify the expense of installing treating plants, the waters are treated by chemicals applied in the roadside tanks or in the locomotive tenders. During 1926, 2,167,365,320 gallons of water were treated in the 36 plants at a cost of $204,150.83, resulting in the removal of 4,334,900 pounds of scale-forming solids at an estimated net saving of $359,386.17 based upon the figure of thirteen cents per pound for solids removed, as adopted by the A.R.E.A.

The above does not include the saving effected by reason of treating the water by chemicals, applied in the roadside tanks or in the locomotive tenders for the removal of scale or the prevention of pitting and corrosion.

On one division where the waters are all corrosive, it was necessary to renew the flues in the stationary boilers after eight months' service. Locomotive flues and fireboxes were renewed on an average of 40,000 and 157,000 miles, respectively. Since the introduction of anti-corrosive compound, the flues in the stationary boilers require removal after four years' service and about 75 per cent are scrapped. The locomotive flues average about 95,000 miles and from 30 to 50 per cent are scrapped, the entire firebox will require renewing on an average of 202,000 miles. Prior to the introduction of the anti-corrosive compound we were securing an average of 15,303,455 miles per bursted flue failure per year; at present we are securing 35,145,548 miles, an increase of 19,842,093 miles per bursted flue failure per year.

The increase in the service secured from the flues and firebox sheets represents an expenditure of approximately $18,000 per year, covering the cost and handling of the chemicals. The saving effected in so far as the maintenance and renewal cost are concerned is easily computed, but as previously stated, it is the savings of an intangible nature such as the elimination of engine failures, decreased overtime for crews, traffic delays, etc., which are difficult to estimate in order to arrive at the total benefit accruing to the railway through improved water conditions.

THE TREATMENT OF WATER FOR LOCOMOTIVES FROM THE STANDPOINT OF THE CHEMICAL ENGINEER

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Broadly considered, the treatment of water for locomotives consists of clarification to remove suspended matter, and softening to remove the scale-forming salts. For the purpose of discussion in this paper, treatment can be restricted to mean softening only. The clarification of stream water is an important problem in railway water supply, but the problems involved in sedimentation and filtration are a separate topic and will not be considered here except as they are a part of the softening process.

There is a great variety of ideas as to the correct methods for water treatment. On railways, these may be classified as partial and complete. Partial treatment is usually accomplished by the use of boiler compounds or soda ash. Of boiler compounds there are many. A new one appears almost every week. Most of them have some virtue and are usually applied in the tender of the locomotive, and there react with the water when they have slowly dissolved.

A typical boiler compound contains some alkali, usually some kind of tannin extract, and frequently silicate of soda which is also strongly caustic. The alkalies neutralize the half-bound carbon dioxide, and partially or wholly precipitate the bicarbonates of calcium and magnesium. Soda ash which is usually present precipitates part of the sulphates of calcium and magnesium, and some of the other ingredients may precipitate some of the scale-forming material as a sludge, such that it will not form a hard scale. The tannin extract is presumed to absorb some of the free oxygen, but the amount is usually not sufficient to have any very pronounced effect.

Some boiler compounds contain a great variety of substances which have no very direct relation to the actual softening process. Through some fancied idea of the manufacturer, or in order to produce a compound which will differ in appearance from the others, and on which a selling talk can be made with a somewhat obscure background of facts, these substances, which have no value whatever, are often added. Some compounds, having a certain value, are somewhat misused in boiler compounds; such, for example, as sodium silicate which often appears in diluted and colored form and occasionally in full strength, and the buyer is told that the material contains no free alkali. It is a well-known chemical fact that sodium silicate has a very strong caustic alkalinity and any such argument is false.

If used in boilers with full knowledge of the material, a certain benefit can be derived, although it is hardly to be recommended as an extremely efficient boiler compound. One of these sodium silicate compounds, with many claims attached to it, was thoroughly tested by the U.S. Railroad

Administration a few years ago, and its use was condemned, not because it was utterly worthless but because it did not fulfill the claims made for it.

In using boiler compounds it should be understood that it is only a partial treatment and that results are not to be expected that will be comparable to the use of a water with practically all of the incrustants removed.

A number of railways make boiler compound for their own use, and thus effect a considerable saving. This, however, should not be done except by someone who has made a study of such materials and who will carefully follow the application so as to secure the most satisfactory results.

Another method of partial treatment which has been in use in recent years is by the addition of soda ash or some compound containing soda ash, in the wayside water tank. A certain amount of the hardness may be precipitated here, although in cold waters there is not much precipitate formed until the water enters the boiler. It is readily seen that in such cases all of the precipitate forms in the boiler and an excessive use of the blow-off will be required to handle such treatment. It is the judgment of the writers that it is not feasible to try to make water softeners out of locomotive boilers. While some relief can be obtained by such internal treatment, such, for example, as adding sufficient amount of soda ash to convert all of the sulphate hardness into carbonates, it cannot be expected to accomplish the results of complete treatment, nor can the water be as successfully handled when the engineer is required to effect the sludge removal from the engine rather than from an outside tank. The use of anti-foaming compound is sometimes practiced with such treatment in order to reduce the foaming introduced by an excessive amount of sludge. Considering the excessive use of the blow-off, with its waste of fuel, and the use of an additional compound to reduce foaming, together with the fact that scale formation has not been completely eliminated, it must be concluded that this method is simply a palliative measure and should be used only with a full understanding of this fact.

The complete treatment of water may be obtained by the use of water softeners, either by the lime-soda, zeolite, or barium methods. The use of barium treatment has never been very extensive. This is due to the high cost of barium salts combined with the fact that barium is decidedly toxic, and there is always a chance that unless treatment has been complete, and clarification perfect, this may be a source of trouble. Barium treatment is only advantageous when there is a large amount of incrusting sulphates which barium carbonate will remove without leaving an equivalent amount of sodium sulphate in the water.

Zeolite treatment, which consists of passing the water through a bed of sodium zeolite, which exchanges its sodium for the calcium and magnesium content of the water, has been largely confined to laundries and the textile industries. As a softening process, it is very effective, and can be made to produce water of practically no hardness. In order to have effective zeolite

treatment the water must not be turbid nor contain excessive amounts of iron compounds. It is therefore necessary to filter such water before passing through the softener. Zeolite treatment was tried a number of years ago on one of the railways but was abandoned. It is now in use to a limited extent on one railway but has not been in operation for a long enough period of time to judge results.

There are certain theoretical considerations which must be taken into account in the application of this process to railway service. In general, the action of a zeolite softener is to exchange the bicarbonates of calcium and magnesium, and the sulphate of calcium and magnesium, for the corresponding sodium salts. There is, therefore, no appreciable reduction in the total solids of the treated water. Since the majority of hard waters carry a considerable amount of bicarbonate hardness, most zeolite treated waters have a large excess of sodium bicarbonate.

The greater the amount of sodium salts in solution, the greater will be the tendency to foam, and sodium bicarbonate especially aggravates this trouble. The zeolite method has the advantage of being very convenient to operate but in most cases the operating cost exceeds that of the lime-soda process. It is also very important in operating such a softener for boiler purposes that the calcium and magnesium chloride brine, which is a product of regeneration of the zeolite with salt solutions, be thoroughly washed out of the softener before it is again put in operation. There may be certain places in railway service where the zeolite softener can be successfully and advantageously used, but this field is extremely limited and it is the general opinion of railway water engineers that some form of the lime-soda water softener is better adapted to general railway use.

The lime-soda water softener has been used in railway service for more than 25 years. However, the design and efficiency of this type of softener has been greatly improved as a result of careful study of the operation of many machines during this period of time. The writers are still operating some softeners of this type that were built in 1903, and though they have been changed in no way, they are giving reasonably good results.

The theory of operation of the lime-soda softener is quite generally understood. The bicarbonates of calcium and magnesium are broken up and precipitated by lime. The sulphates of calcium and magnesium are converted into carbonates by the addition of soda ash, and the magnesium carbonate finally converted to magnesium hydrate by more lime. With sufficient agitation and reaction time, and proper filtration, clear soft water is obtained. The bicarbonates of calcium and magnesium are reduced to a minimum of about one and one-half grains per gallon, and sulphates of calcium and magnesium are converted to sodium sulphate. The ideal result cannot be uniformly obtained by the use of lime and soda alone.

The chemical reactions involved in the softening operation follow the law of mass action, and are very definitely accelerated by heat and retarded by cold. In the winter months it is extremely difficult to reduce the hard-

ness of a refractory water as low as desired for boiler use without the addition of some reagent to drive the reaction further toward completion.

The use of sodium aluminate has recently been introduced for this purpose and with marked success. Added after the other chemicals have had a chance to react, it reacts quickly with the residual calcium and magnesium salts, producing a good floc which assists in carrying down the precipitate already formed, and effects a completeness of reaction which has not been possible in cold solutions with the ordinary treatment previously applied. In order to obtain complete precipitation in any case it is necessary to add a reasonable excess of the reagents that bring about the softening process.

On the other hand, the operation of locomotives require that too great an excess alkalinity in the water should be avoided, as this, combined with precipitation which accumulates in the boiler, may induce foaming. However, it is important that water be treated completely because incomplete treatment gives rise to after-precipitation which causes trouble in pipe lines and in the boiler. From this it is seen that in railway water softening it is necessary to study this reaction carefully and learn just how far the softening should be carried to effect the best results.

Some municipal softening plants introduce carbon dioxide into the treated water to prevent after-precipitation and to improve the taste, but this has never been shown to be profitable in handling water for boiler feed purposes.

A great deal of study has been given to the methods of applying the chemicals to the water, as well as the mechanical handling of the water during the entire softening process, and this has been proven to be just as important as the use of the correct amount of chemicals themselves.

The ordinary softening practice in a ground-operated machine is to mix the lime and soda ash with water in a chemical mixing tank. This is then pumped, either after dilution with soft water or as it exists in the mixing tank, to the top of the softener, where it is mixed with the incoming raw water. Proportioning devices control the relative amounts of this chemical mixture and the raw water going into the downtake. This mixture is sometimes agitated by paddles and sometimes allowed to pass to the bottom of the downtake without agitation, the time in the downtake being such that the chemical reaction is practically completed when the water reaches the bottom of the tank.

After the water leaves the downtake, it spreads over the larger area of the outer shell of the softener, and the upward flow is thus retarded. This upward flow being much slower than the downward flow, the precipitate gradually settles to the bottom. As this precipitate accumulates in the bottom it is removed by a sludging system, usually consisting of a series of pipes covering the bottom of the softener, with small openings such that the sum of the area of these openings does not exceed the total area of the open sludge valve. This valve consists of a quick opening gate valve, in order to get quick movement of the sludge over all parts of the tank bottom.

As the treated water flows slowly upward and the scale-forming ingredients are precipitated, the water at the top of the tank becomes clear. It is the writers' policy to have an excelsior filter at the top of the softener which completes the clarification of the water in case any light particles are carried to the top.

There is a great deal of difference of opinion on the excelsior filter. Many say that it is old-fashioned and inefficient. The writers began the use of such filters 25 years ago, and have learned many things in the operation and maintenance of this method of clarifying softened waters. As a result of this experience this method of filtration has been installed in the three latest type plants that have just been completed and put in operation.

The practice here outlined in the water softening process is subject to much variation in practice according to opinions of operators and designers. Some machines can be successfully and conveniently operated from the top so that the chemical solutions flow by gravity as they are measured into the downtake. In some cases it is advantageous to have separate chemical tanks from which the lime and soda ash may be added separately. If alum is used, a third chemical tank is a necessity as this chemical or sodium aluminate should be added after the other two chemicals have reacted.

The velocity of stirring in the downtake or other mixing chamber is an extremely important factor in successful water treating, and depends upon the character of the water and the chemicals used. As a rule, violent agitation is injurious to the precipitate formed as it breaks up the floc and does not give a precipitate that will settle as completely as if a longer period of more gentle stirring is used. In such a case a flocculent precipitate is developed, the reaction is completed, and when the mixture goes to the settling chamber, the precipitate settles rapidly and completely.

Recently several horizontal type water softeners have been designed and installed for railway service, concrete being the material of construction. In these softeners the raw water and chemicals are introduced into a baffled race, the speed of flow being calculated so as to give the proper amount of agitation, and the best floc to the precipitate. The chemicals can be introduced at any point in this race that seems to be most desirable, and can be introduced separately if desired. The time in this mixing chamber is approximately one hour. From this the water is discharged into a settling chamber where it is held for one hour, and in which a very large percentage of the sludge is removed. This chamber has a sludge removal device by which most of the sludge is removed daily. There is attached to this chamber a pumping device for repumping a portion of the sludge. This is added to the mixing chamber where the water is introduced, and helps to develop a more desirable precipitate. From the first settling chamber the water passes to a larger chamber where it is held for several hours and from this to the filters.

Some treated waters are used without filtering. This, however, presupposes a large settling capacity, and a very complete reaction, together with

perfect operation. It is well to have a filter at the end of the process as a matter of safety so that any slight disturbance in the operation will not permit turbid water to pass through into the storage tank. This is particularly advantageous during times of peak business when it may be necessary to operate the softener beyond its rated capacity.

While sand filters are a more perfect means for clarifying turbid water, it has been found for railway use that the excelsior filter gives entire satisfaction, costs less to install, less to maintain and requires less attention from the operator.

In the treatment of water for locomotives, there are several important problems to be given consideration other than the mere removal of incrusting solids. Even though the scale-forming ingredients have been removed, there may be difficulty from other sources. A clean boiler may be a fertile field for pitting and corrosion if the elements causing such troubles are present. This problem has and should engage the attention of railway chemists for a long time. Iron dissolves in water with the evolution of hydrogen, provided the products of the reaction are removed. Otherwise the iron becomes polarized by the hydrogen and the reaction stops. If, however, oxygen is present in the water, the nascent hydrogen will combine with the oxygen and the reaction will continue as long as oxygen is available. Practically all natural boiler feed waters carry oxygen in solution. It is therefore continuously supplied to the boiler. While the amount is very small, ranging from perhaps five to ten cubic centimeters per liter, it is nevertheless sufficient to do a great deal of damage.

If corrosion were uniform over the entire interior surface of the boiler, the trouble would not be so aggravated, but owing to the lack of uniformity of the metal, and the fact that there may be strains in flue shoots, firebox, knuckles, and seams, the corrosion tends to localize and is then reported as pitting or grooving, according to the shape of the corroded area.

The theoretical considerations upon which this thesis is founded are quite familiar, and are ably borne out by experimental evidence. This excludes, of course, that corrosion due to acid water, which is not under consideration here.

Various attempts have been made to eliminate the oxygen from locomotive feed water without pronounced success. Open feed water heaters have been used for some time, and there is wide divergence of opinion as to whether or not they eliminate any considerable amount of oxygen. The indications are that much depends on the manner in which the feed water heater is handled. More definite results will be forthcoming when certain tests now running are completed. One of the best remedies at present for oxygen is to carry an excess of caustic soda in the treated water. It is important that this alkalinity be caustic rather than carbonate because there seems to be some evidence that at high temperatures and pressures, sodium carbonate breaks down into caustic soda, organic matter, and free oxygen.

This free oxygen would then be available as a corrosive agent. This is the explanation offered by J. H. Paul in his book on boiler chemistry.

At any rate the writers know that a boiler operating on water containing an excess of sodium carbonate at high temperature and pressure develops caustic soda and organic matter, and shows some evidence of corrosion of the general, rather than the pitting type. A caustic alkalinity should therefore be maintained in the treated water to prevent this action.

Another difficulty met with in the use of treated water is foaming. Foaming is a function of the concentration of dissolved and suspended solids in the boiler. It may be relieved by frequent use of the blow-off, or the judicious use of anti-foaming compound. The best anti-foaming compounds depend upon castor oil contained in the liquid as an emulsion. A water completely treated by the lime-soda process, carrying a moderate excess of caustic alkalinity, should give less trouble from foaming than waters containing boiler compound or hard waters carrying high dissolved solids. This is because such water contains the smallest amount of dissolved and suspended solids.

Anti-foaming compound should be used sparingly, i. e., not until the water begins to give trouble; thus, the excessive use of compound may be avoided. The writers have seen engines where so much anti-foaming compound has been used that the boiler actually became compound dirty. This makes it more difficult to control the foaming after that point is reached.

The advantages of water treatment in the removal of scale, the increased life of flues and fireboxes, the reduction of engine failures due to boiler troubles, and the consequent improvement of railway operating efficiency, are too well-known to require individual comment here. Suffice it to say that with the present trend toward higher boiler pressures, longer engine runs, higher speeds, and greater train loads, what is now considered efficient operation would be impossible without adequately treated water. Much has been written of water treatment, and much more has been said, but from the standpoint of the chemical engineer, the real problems of water treatment are solved by faithful field supervision and competent laboratory investigation and control.

BOILER FEED WATER TREATMENT FROM A MANUFACTURER'S VIEWPOINT

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In the manufacture of boilers, as in other lines, it is necessary to meet a number of demands set forth by the ultimate user. These cover quite a range. As water works chemists, we will confine ourselves to those arising from the impurities in feed water.

The principal troubles caused by these impurities are:

1. Scale
2. Corrosion
3. Embrittlement
4. Priming and foaming.

Scale in boilers is responsible for lowered efficiency, blistered and ruptured tubes.

Corrosion results in a thinning of the metal that may cause its early failure, or it may result in the lowering of the safe working pressure, thereby impairing the usefulness of the boiler.

Embrittlement manifests itself by a cracking of the plate with the necessity of replacing same.

Priming or foaming causes wet steam, or, in extreme cases, slugs of water, to pass over to the engine, with its attendant dangers and evils.

The cause of these conditions lies in the nature and extent of the materials found in water. Whenever a municipal water supply is laid out or extended, a search is made for an abundant supply of water that will meet the most exacting sanitary requirements. Until quite recently, no attention was paid to the chemical analysis of the water, and from the viewpoint of boiler feed water purposes, this is the most important analysis.

In boiler operation, it is very common practice, whenever possible, to connect to the city water supply. From an economic viewpoint, this is, perhaps, unfortunate, as it means that water of a high purity when viewed from a sanitary viewpoint, is being used for purposes where such purity is of no moment. Inasmuch as we are dealing with boiler feed water, we will consider only the chemical purity of the water.

The mineral matter present in most waters consists of a few bases and acids so combined as to give quite a number of different compounds. The bases usually encountered are the alkaline earths, calcium and magnesium—the alkalies, sodium and potassium, which for convenience we will refer to as sodium, and usually a small amount of iron. Quite a number of other bases are occasionally encountered; however, due to the small amount present they are usually, from a boiler feed water viewpoint, of slight consequence and as a rule their presence is overlooked. The

acid radicals that are present are bicarbonates, occasionally carbonates, sulphates, chlorides and nitrates.

Calcium bicarbonate and calcium sulphate are encountered in the great majority of all feed waters. Calcium chloride occasionally, and calcium nitrate is only rarely found. Magnesium compounds—magnesium bicarbonate is about as universal a constituent of water as is calcium bicarbonate. The sulphate, although present in many waters, is absent in many cases where calcium sulphate is present. On the other hand, magnesium chloride is a much more common constituent than is calcium chloride.

In certain well-defined geological districts, sodium bicarbonate is a common constituent; such waters, however, represent only a small portion of the total supply. Sodium sulphate and sodium chloride are found in practically every instance, and in very small quantities. Sodium nitrate is a common constituent.

In addition to these minerals, there is always a small amount of iron, silica and organic matter present.

Before taking up the effect of these minerals, let us consider how they come to be present in surface and ground waters. The purest water found on the earth's surface is that of rainfall and melting snow and ice; even these do not retain their purity very long as they readily absorb carbon dioxide from the air, which, when in solution, forms carbonic acid. At the same time, there is a dissociation of the water into ions, giving the water an acid reaction and thereby increasing its facility to dissolve mineral constituents. As such a water passes over deposits of calcium and magnesium carbonate, which in themselves are quite insoluble, the dissolved CO_2, or carbonic acid, causes a certain amount of the carbonate to dissolve as calcium or magnesium bicarbonate. Calcium and magnesium sulphates, particularly the latter, being of a more soluble nature, are common constituents. Due to the high solubility of calcium and magnesium chloride, and all sodium salts, it can be expected that water will readily dissolve considerable quantities of these minerals whenever it flows over or through such deposits.

In view of the foregoing statements and the large watersheds drained by many rivers, it would be expected that most water would be pretty well saturated with all of these constituents. Fortunately this is not so, the reason being there is almost an entire lack of various minerals in different parts of the country. Throughout New England, for example, most everything is granite, the result being that the waters are of very high purity; calcium and magnesium salts are met with in very small quantities and in many instances sodium bicarbonate is found, resulting from the decomposition of certain minerals. Along the seaboard, it is a common occurrence to find both magnesium chloride and magnesium sulphate, due to the infiltration of sea water. The coastal plain from Virginia to Texas contains a great deal of sodium bicarbonate water. As we go inland there is an increasing amount of calcium and magnesium bicarbonate and calcium sulphate. This is due to the different earth formations, whereby there is

a greater abundance of limestone, gypsum and other minerals readily soluble in water. The extent to which these various minerals are present also varies to a very marked degree. In some instances, the amount of calcium and magnesium salts that are present is so great that the waters are so hard as to be almost useless, and in other cases there is so much alkali present that the water is equally useless.

Surface waters being chiefly run off from recent rainstorms or melting snow and ice are, as a usual thing, much purer than the underground water from the same territory. As the water seeps down through the earth's crust, it is constantly dissolving minerals until it finally becomes heavily charged with minerals.

What is the effect of all of these minerals from the boiler manufacturer's viewpoint? In the first place, the boiler user is interested in obtaining steam for some specific use. He knows that he has water enough present to meet his requirements, and he expects his boiler to function irrespective of the quality of water available. This means that the boiler is expected to function with equal efficiency when the water varies from excessively hard to the extremely soft or excessive alkaline waters, and ways and means must be devised whereby the water can be put in such form that it will not cause any trouble. Now, then, let us turn back and consider the various minerals present and see what effects they have on boiler operation.

Calcium and magnesium bicarbonate represent a somewhat unstable condition. There are, in reality, calcium and magnesium carbonate held in solution by the presence of carbonic acid. Therefore, any condition which will remove the carbonic acid will immediately result in the precipitation of the calcium and magnesium carbonates. Fortunately, boiling water, at atmospheric pressure, will not hold gases in solution. Therefore, if water is heated to the boiling point, held there long enough for the gases to escape, we can expect a rather complete removal of the calcium and magnesium bicarbonates. If, on the other hand, the water is pumped direct to the boiler without sufficient preheating, then we can expect the carbonate to precipitate within the boiler. However, this usually takes place in the cooler parts and the resultant sludge settles out in the muddrum, where it can be readily blown out as a soft sludge.

In the event that care is not taken to prevent this calcium or magnesium carbonate from settling out on the heating spaces, a troublesome scale will soon build up.

Calcium Sulphate.—This material has a decreasing solubility with increase in temperature; this results in its precipitation at the hottest points, which, in the case of a water tube boiler, are those tubes nearest to the fire. The material also readily adheres to the steel tubes and acts as an excellent insulator, preventing the heat being transferred from the steel to the water. The result is a rapid heating of the metal to a point well in excess of the water temperature, frequently reaching such a temperature that the steel loses its strength, bulges, forming a so-called blister,

and eventually ruptures. When the tube swells or bursts, it cracks the layer of calcium sulphate, permitting the water to reach the hot tube, forming in the case of a blister, a steam pocket underneath the scale, or, if the tube has ruptured, there is a sudden flow through the opening. In both cases, the effect is the same; namely, all signs of scale are removed from the immediate neighborhood, and this leads many engineers and boiler operators to believe that the trouble is due to defects in the steel and not to the presence of scale, and they point, with considerable emphasis, to the fact that in the immediate location of the blister or rupture, there is no scale present. Investigation shows that the steel is entirely satisfactory in the presence of scale in other parts of the boiler.

In many cases, when calcium sulphate is precipitated, it mechanically entraps a good deal of calcium carbonate, silica, suspended matter, etc., which has not settled out to the muddrum; the result is a combination of sulphate and carbonate scale, the effect of which is the same as already described.

Magnesium Sulphate is quite soluble and is not a scale-forming constituent; on the other hand, it has corrosive tendencies which result in the formation of pits and serious damage to the steel parts.

Calcium Chloride.—For obvious reasons this mineral will be considered with—

Magnesium Chloride.—This material is extremely troublesome; the general accepted theory is that it goes through a cycle, the net result of which is that a little bit can do an awful lot of harm. We will not concern ourselves with the theory or its reaction; instead, we will confine ourselves with the result.

Whenever magnesium chloride is introduced into a boiler and no steps are taken to offset its action, corrosion results. Typical pits are quickly formed and these eventually become deep enough to penetrate the metal and necessitate replacement of the part in question.

Sodium Bicarbonate.—This compound is not scale-forming nor corrosive in the usual accepted meaning of the word. However, due to its eventual hydrolysis to sodium hydrate, it can be classified as a harmful element. Those interested are referred to the voluminous literature which has been published on the question of the action of sodium bicarbonate waters.

Sodium Sulphate and Sodium Chloride.—These two salts are present in practically all waters; they are rarely considered corrosive and are not scale-forming unless the concentration is excessive. In the presence of oil, soap or suspended matter, sodium salts are very troublesome from the viewpoint of priming and foaming. Iron, although present in almost every water, is of no moment as far as boiler feed waters are concerned, unless it happens to be present in the form of ferrous sulphate, under which conditions the problem is really that of sulphuric acid corrosion.

Invariably we find a small amount of silica present in all waters; as a rule it is of no moment. However, there are many cases where it becomes a very serious problem, especially as it frequently forms a calcium magnesium silicate which produces a very troublesome scale.

In many parts of the country where muddy waters are common, we have a burden of suspended matters; this may readily settle out, give little or no trouble, or it may come down as a hard scale and in some cases it finds its way to the surface of the water where it becomes extremely troublesome as a priming and foaming agent. The nature of this suspended matter varies quite materially; it may be a fine colloidal clay, in which case it is most difficult to remove. On the other hand, it may be more of a suspension and therefore it can be removed by filtration.

The foregoing covers all of the minerals usually found in natural waters. In coal mining districts we are confronted with the problem of acid waters due to the oxidation of pyrites into ferrous sulphate. This, as previously stated, is in reality a sulphuric acid problem, the result in both cases being extensive corrosion. In many cases we also have to deal with the question of trade wastes, which may contain most anything—acids, alkalies, oils, organic matter, etc.

From the foregoing it can be seen that almost every salt that is present in water is troublesome in one way or another. Calcium salts are the chief scale-forming constituents. Magnesium salts are the chief corrosive agents. Sodium salts, although in some cases quite harmless, have an embrittling action and at the same time they can be considered as one of the principal causes of priming and foaming, being aided in this latter characteristic by the presence of oils, soaps, sewage and suspended matter. This might lead one to say—why not use pure water at all times? This, at first glance, sounds like a "cure-all."

When surface condensers first came on the market, engineers felt that with a feed water at least 95 per cent distilled, that our troubles were virtually over, especially as certain plants decided to evaporate the make-up, thereby having the feed water 100 per cent distilled. This brought about a new set of complications; it was soon realized that very pure water was corrosive from two viewpoints:

1. Due to the presence of dissolved oxygen.
2. Due to the presence of hydrogen ions.

The former is particularly troublesome in connection with feed lines, heaters and economizers; the latter is troublesome throughout the entire cycle of the boiler.

An ideal feed water is one that is neither scale-forming nor corrosive and will not cause embrittlement, priming nor foaming. Unfortunately, such waters do not exist, and it therefore becomes necessary to treat the existing supplies so that they will conform to these requirements. This is accomplished by various treatments. In many cases, the treating is done outside of the boiler, and therefore permits making a thorough job.

In other cases, efforts are made to treat within the boiler; the results are never as good, because no boiler is a chemical stew pot.

The user, in order to maintain his boilers at their full efficiency, must eliminate the corrosion in feed lines, economizers and certain parts of the boiler, which is due to corrosive salts or gases within the feed water; the scales and sludges within the boiler proper, due to certain salts in the feed water; as well as priming or foaming, due to the presence of certain salts, oils, etc.

SEDIMENTATION WITH AND WITHOUT CHEMICALS, PRESSURE AND GRAVITY FILTERS, DECONCENTRATORS AND CONTINUOUS BLOW-DOWN APPARATUS

Progress Report of Joint Research Committee on Boiler Feed Water Studies

I. SEDIMENTATION WITHOUT CHEMICALS

Purpose.—This method of water purification, also known as plain sedimentation or natural subsidence, refers to the clarification of muddy waters by quiescent standing or by slow passage through tanks, basins, or reservoirs. No limiting amount is suggested here for permissible suspended solids in boiler water, because of the many variable factors, such as character of the sediment, type of boiler, rate of evaporation, and kind and amount of soluble salts present.

Significance of Suspended Matters in Boiler Waters.—The suspended matter in surface water is made up of clay, silt, or even fine sand particles, together with some organic débris. The amount of suspended solids in American rivers ranges from a few parts per million to 30,000 ppm or over, for some of the streams in the middle west. The best comparative data available is that contained in Water Supply Paper 236 of the U.S. Geological Survey, which shows a general average for 95 typical surface waters (mostly rivers) in the region east of the Rockies.

Suspended matter affects the boiler plant in three ways. First, it increases the mineral constituents present in the boiler and is occasionally entrained with the crystalline formation of scales to increase the bulk and effect "mud burns." This is particularly true when such suspended matter is of the sticky or "gumbo mud" type which is sometimes present in sufficient quantity to alone cause serious damage to flues and sheets. Second, the presence of such material will increase the tendency toward foaming when present in connection with appreciable amount of alkali salt concentration. Third, it tends to stop pipe lines and causes unnecessary wear on valves and pumps.

Sedimentation by Natural Storage.—Where the water supply is secured from a sizable impounding reservoir, such reservoir provides a natural sedimentation basin and additional sedimentation is not helpful. However, where a turbid supply is taken directly from a stream, it is usually advantageous to provide a subsiding period.

Sedimentation in Artificial Basins.—Simple clarification without chemicals is usually carried out in artificial basins or tanks having a capacity or detention period equivalent to several hours' or even several days' consumption. The efficiency of such subsidence is quite variable according to the quality of the suspended matter present in waters from various parts of the country, or even in the same stream from time to time. Fig. 1 shows typical results on several of the turbid western waters which carry a rela-

tively high amount of suspended matter where the advantages of plain sedimentation are therefore most obvious. Suspended solids high in sand are usually adaptable to such treatment, but it should be recognized that there are many streams of fairly high turbidity where the suspended solids are so finely divided or colloidal as to make it unprofitable to attempt sedimentation without the use of coagulants. In each individual case, the cost of providing capacity for plain sedimentation must be balanced against the benefit to be gained and the feasibility of the same degree of purification in smaller tanks or basins by the aid of chemicals.

II. SEDIMENTATION WITH CHEMICALS

Purpose.—When satisfactory clarification cannot be obtained in a reasonable time by plain sedimentation, it then becomes necessary to use a chemical coagulant to assist in the precipitation of the suspended solids.

Action of Chemical Coagulants.—The chemicals useful for clarification are certain soluble metallic salts which react with alkaline substances to yield insoluble and gelatinous hydroxides. Aluminum sulphate or "filter alum" is the most generally used coagulant. It is obtainable on the market in the form of lumps or powdered, and in 200-lb. sacks, 400-lb. bbls., or in bulk carload lots. Its value depends upon the content of water soluble alumina (Al_2O_3) which, in commercial grades, averages about 17 per cent.

When aluminum sulphate is added to natural waters it reacts with the bicarbonate present to give a precipitate of aluminum hydroxide which has the effect of coagulating or flocculating the particles of suspended clay and silt so that the water easily clarifies on settling. The reaction when bicarbonate is expressed as "alkalinity," is as follows:

$$Al_2\ (SO_4)_3 - 18H_2O + 3\ CaCO_3 = 2Al\ (OH)_3 + 3\ CaSO_4 + 3\ CO_2 + 15H_2O.$$

It is of special interest to boiler users to note that in this reaction the permanent hardness is increased. In other words, each grain per gallon of aluminum sulphate used theoretically decreases the alkalinity by about one-half grain per gallon and increases the sulphate or non-carbonate hardness by the same amount. If there is insufficient alkalinity present in the natural water to provide for more than an excess required for the alum treatment, it becomes necessary to add lime in addition to the alum in order to form the necessary hydroxides.

Another coagulant used to a considerable extent is ferrous sulphate, or copperas. It is available in the market principally as "sugar sulphate of iron" ($Fe_2\ SO_4 - 7H_2O$), in bags, barrels, or bulk carload. When added to natural waters the salt decomposes to form iron hydroxide, a reddish gelatinous precipitate, but the precipitation is seldom complete unless lime is also added to neutralize the free carbon dioxide. The use of iron sulphate decreases the alkalinity and increases the sulphate hardness in a similar manner to aluminum sulphate. It has the advantage over aluminum salts when used to hasten clarification after softening with lime and soda, in that its hydroxide is not soluble in the presence of caustic lime.

During the past few years there has become commercially available various modifications of sodium aluminate, some of which appear to give better and more effective results on certain waters than either alum or copperas. The aluminates have the advantage in producing coagulation without increasing the sulphate or non-carbonate hardness and also have the inherent property of softening the water to a limited extent. When used with lime and soda ash at water softening plants to speed up the chemical reactions and clarification, it appears to be peculiarly efficacious in breaking down the double complex magnesium salts and permits a lower residual hardness in the softened water without increased addition of alkali salts which are considered detrimental in connection with foaming tendencies. Reports have also been received that considerable improvement has also been effected in reducing the clogging of pipe lines from after-precipitation.

It may be noted here that lime, although not a coagulant in the sense discussed above, sometimes acts as a coagulant with waters containing relatively high amounts of magnesium. The magnesium hydroxide is found only when the water is made caustic but has coagulating properties similar to iron and aluminum salts, although not to as marked an extent.

It is not felt to be within the province of this committee's report at the present time to deal in considerable detail with the various aspects and troubles encountered with different attempts at chemical coagulation. The subject of colloidal chemistry is not, as yet, sufficiently understood to lay down definite principles and precepts which will apply to all conditions. This subject is still in course of study and investigation, and emphasizes the necessity for competent chemical supervision where such methods are employed in order to obtain best results.

Importance of Mixing.—Best results in clarification are to be had by efficient mixing of chemicals with the water treated and it is usually advantageous to keep the mixture in motion for a period of several minutes after addition of the chemicals in order to allow the reactions to become completed. The advantage of a reaction period is especially apparent in connection with softening operations where lime and soda ash are involved.

Methods of Application.—There are several systems of introducing the chemicals into the water. In small installations where the operation is intermittent on the fill-and-draw principle, it is customary to weigh out the proper charge, dissolve, and add to the tank as it is filled. For continuous flow processes, it is customary to dissolve the coagulant and feed as a solution by orifice box and regulating valve, or by means of an automatic proportioning device.

Where a larger amount of water is treated, dry feed machines may be used to advantage for feeding the coagulant. It is best to have the machines discharge into dissolving hoppers instead of direct to the water.

Doses Required.—For clarification where softening is not involved, the dose of coagulant is only roughly in proportion to the turbidity, and

for turbid waters may vary from one to five grains per gallon (0.14 to 0.72 lb. per 1000 gallons). While ten grains per gallon or over have been used at times, such excessive doses point to the need of plain sedimentation or other preliminary treatment before the coagulant is added.

Retention Period.—After the coagulant is applied and thoroughly mixed, the water is allowed to settle during the period for the flocculated material to deposit. Clarification begins immediately but continues the longer the water is held. Ordinarily a retention period of two to three hours will give satisfactory results where the water is maintained in a fairly quiescent state, although in water works practice where good clarification is expected, the retention period frequently amounts to from six to twelve hours. Where filtration follows coagulation, the retention period may be shortened appreciably. In continuous lime and soda ash water softening plants, this period will average between five and six hours which appears to give satisfactory results when the vertical velocity is kept below 8 feet per hour.

Recommendations.—It is recommended that this be considered a progress report only and that the subject of sedimentation be given further study, particularly with reference to results obtainable with the recently developed types and operation of subsidence tanks with continuous sludge removal which may be applicable to either preliminary or final treatment.

III. PRESSURE AND GRAVITY FILTERS

Purpose.—In water used for steam power purposes, it is usually found desirable to remove all suspended matter possible before the water enters the boiler. Where sedimentation facilities are not available or do not accomplish satisfactory results, it is customary to pass the water through a filtering medium to effect the desired clarification.

Material Used.—In some cases where filters are used in the top of sedimentation tanks, particularly in cases of continuous lime and soda ash treating plants, excelsior has been used for many years with varying degrees of success. Even under favorable conditions, the effective life is limited and the trouble and expense for renewals has caused a tendency to increase the size of sedimentation tanks or change to ground operated sand filters. The filtration facilities for boiler purposes which appear to meet with favor at the present time are the rapid sand filters of either the pressure or gravity type. The essential features are similar in either case in that the filtering medium is graded sand.

Types.—In the pressure type, the filtering medium is enclosed in steel tanks through which the water is handled under pressure. Such system may be placed directly in the water main with suitable connections.

The gravity type consists of either wood, steel, or concrete open-top tanks which hold the graded sand through which the water flows into a clear well and from there is repumped to the distribution system.

Essential Features.—In its simplest form, a rapid sand filter consists of a tub or tank having:

(a) A suitable underdrain system in the bottom for collecting the filtrate without loss of sand, and for distributing the wash water during the cleaning operation.
(b) A thick layer of selected uniform sand constituting the filtering medium.
(c) Suitable gutters or troughs above the sand for removing the dirty wash water.
(d) Suitable pipe connections and valves for controlling the water during the filtering and washing operations.
(e) Suitable facilities for furnishing a reversed flow of filtered water to the underdrain system during washing.

Underdrain System.—The underdrain system for rapid sand filters is still subject to experimentation for the most satisfactory design. In addition to the piping with screened openings, a feature common to all installations is the graded layers of gravel. The total depth of these graded gravel layers will vary from 12 to 20 inches.

Sand Depth and Sizes.—The depth of sand ordinarily varies from 24 to 30 inches. The suitability of filter sand is generally judged by its "effective size" and "uniformity coefficient." Effective sizes range from 0.35 to 0.60 m.m., while 1.5 to 1.7 is commonly specified as the value of the uniformity coefficient.

Ratings and Capacity.—The satisfactory rating for rapid sand filters to be used for waters in boiler plant service will vary from two to four gallons per square foot per minute.

Arrangements for Washing.—The suitable systematic periods for washing can best be determined by observation of the conditions at the individual locations. Care must be taken to control the rate of washing in order not to float the sand bed. For average filters the rate should not ordinarily exceed ten inches vertical rise per minute unless filters are especially designed for higher velocities. Duration of washing will vary from three to eight minutes and amount of water required will vary from one to five per cent of total water filtered.

Growth of Sand Grains.—Particular attention should be given the filter beds where used to handle water from lime and soda ash treating plants due to after-precipitation taking place on the sand grains which causes such growths that frequent renewals of the entire sand bed may be found necessary.

Performance.—The practical limitations of rapid sand filters in respect to the removal of turbidity are governed, in part, by certain controlling factors imposed by the design of a plant and by others incidental to its operation. The more important factors or design are:

(a) Relative adequacy of provisions for proper preliminary coagulation and sedimentation.
(b) Size, depth, uniformity and texture of the filtering medium.
(c) Efficiency of devices for washing and controlling the operation.

(d) Permissible rate of filtration and its constancy under varying losses of head.

FACTORS OF OPERATION ARE:

(a) Effectiveness of coagulation given the water
(b) Rate of filtration employed
(c) Thoroughness of cleaning
(d) Manner of operation
(e) Condition in which the filtering medium is maintained, including rate of sand growth.

Recommendations.—It is recommended that this be considered a progress report only and that this subject of filters be given further study with reference to standardizing on rates of filtration for pressure filters and rates of back wash, and also investigation of developments and results with strainerless filters.

IV. DECONCENTRATORS

The term "Deconcentrators" is a trade name given to an apparatus which filters the suspended matter from the water in a boiler and returns the clarified water back to the boiler under pressure. The equipment consists of a small sand pressure filter through which the boiler water is passed and a small pump is attached in order to overcome the friction losses due to passage of water through the piping and filter sand. Scrapers are provided to prevent the sand from becoming clogged and a back wash system is included, similar to other types of pressure filters.

Experience has indicated that this device performs good service in freeing the water in the boiler from suspended matter and precipitates, and it appears to be peculiarly adapted to increasing the efficiency of boiler plants when the treatment of the water with resulting accumulation of sludge is carried out in the boiler itself.

The term should not be confused with the reduction in the concentration of objectionable alkali salts, as the soluble boiler water constituents are not affected by such filtration.

Recommendations.—The action of this apparatus should be given definite study under service conditions and information should be presented to show where such installations may prove adaptable and economical.

V. CONTINUOUS BLOW-DOWN APPARATUS

Purpose.—With the evaporation of water in steam boilers the pure water leaves the boiler as steam and the dissolved or suspended impurities originally present in the make up water remains in the boiler water in a proportionally accumulating amount. When this concentration has reached a certain point, governed by conditions at the individual plant, foaming or priming occurs which seriously affects the plant operation.

Ordinary Handling.—It is the usual practice, both in power plant and locomotive operation, to control the concentration of objectionable impurities by periodical blow-downs and finally by complete change of water

or boiler washout. This involves expense in plant operation and loss of power while boiler is out of service for cleaning.

Continuous Blow-down.—To avoid uneven operation caused by the large variation in concentration which is brought about by heavy periodical blow-downs, various systems of continuous blow-down have been suggested. This increases the smoothness of operation as it tends to insure a constant density of the boiler water.

An ingenious application of this principle which appears to have met with favorable consideration in foreign installations, consists of a combination continuous blow-down and sludge removal system from which the heat is recovered and returned to the boiler through application to the incoming feed water. It is claimed that such a device makes it possible to maintain continuously in the boiler the best conditions for smooth steam generation and permits a close control over the variations in the salt and sludge concentration. Claims are also made that the heat lost by ordinary periodic blow-downs is largely conserved and that 15 to 20 per cent of the water removed is recovered in the form of condensate.

Recommendations.—There appears to be a considerable field for effecting economy in power plant operation through the improvement and standardization of suitable means for controlling the alkali salt concentration in boilers. The importance of this subject appears to warrant special study and close review of existing devices which are in service in this country as well as foreign developments in this field.

PRETREATMENT OF BOILER FEED WATER

Progress Report on Water Softening by Chemicals (External Treatment)

(A) OPERATION OF CONTINUOUS AND INTERMITTENT LIME-SODA WATER-SOFTENING PLANTS

The investigation of this subject has necessarily been broadened somewhat to include a study of the typical equipment employed in each type of softening plant, in view of the intimate relation existing between the installation and operation in both cases. As any manufacturer of water-purification equipment may build either the continuous or intermittent type of apparatus, subject only to the limitations of his technical knowledge and engineering skill, it was felt that an impartial study of this important angle of the problem could be made.

A typical continuous softener, as its name implies, provides for the continuous treatment, settling, and filtration of a water at either a constant or variable rate of flow through the apparatus. Ordinarily the retention period provided is four hours, with the softener running at its full rated capacity, although in some cases this has been decreased slightly and in others has been materially increased.

The typical intermittent softening plant comprises two or more tanks which are filled, treated, and emptied by the batch method, together of course with the necessary auxiliary equipment. In this case also the minimum time for which each tank is in service is 4 hours; but in this case a half-hour is provided for filling the tank, a minimum of 2½ hours for settling, and one hour for emptying. The service period of each tank and the number of tanks is frequently increased.

Comparison of Equipment

Size of Reaction and Settling Tanks.—The typical intermittent plant requires a total tankage of at least 50 per cent more than the continuous plant, and usually requires at least twice as much floor space.

Storage.—Since a tank of the intermittent plant must be emptied rapidly, in order not to waste the settling capacity of the tank, provision is generally made to accomplish this emptying in not more than an hour. The treated water is discharged through filters into a clear-well with a capacity usually equal to 1½ to two hours normal water consumption or more.

Obviously the continuous softening plant does not require storage of this sort, since it is delivering treated and filtered water uninterruptedly and can meet the demand as it occurs.

Filters.—Assuming that an intermittent tank holds a four-hour supply of water and is emptied in one hour, it is obvious that considerably greater filter capacity must be provided than for the continuous softener in which the same total quantity of water is distributed over a four-hour period.

Pumps.—If pumping of the raw-water supply to the softener is necessary, the intermittent plant will require pumps with about four times the capacity of those needed for the continuous plant, since the volume of water pumped into one of the intermittent tanks in an hour is distributed in the case of the continuous plant over a four-hour period. Much of this head is lost in the case of the intermittent plant due to the decreasing head as the tank is drained. In the continuous plant, with a draw-off of the treated water at the top of the tank, the head is retained in large measure.

Mixing Chemicals with Water Being Softened.—In the continuous type of apparatus, where a relatively small amount of water is being treated at any given moment, it is not particularly difficult to secure good mixing of the chemicals with the waters being softened. In the intermittent system, in which the entire tank supply is treated at once, special provision must be made for the distribution of the chemical reagents throughout the large mass of water being treated. In small plants mechanical stirrers may be employed. In larger plants, compressed air is usually the agent employed for agitation, a compressor and auxiliaries thus becoming an essential unit in this type of plant.

Initial Cost.—The initial cost of an intermittent plant, installed, of reasonably large size, to meet the requirements of boiler-feed-water purification, will average from about 30 to 50 per cent more than for a continuous plant of the same hourly capacity. The difference in the overhead expense of the two plants thus becomes an item of importance in considering the operation of the apparatus.

Comparison of Operation

Cost of Chemicals.—The amount of chemicals required in either case is approximately the same. It is standard practice in the case of the intermittent plant to employ a coagulant, usually sulphate of iron, in addition to the lime and soda required for treatment. The use of a coagulant is not standard practice with all continuous plants, but the evidence in many cases indicate that the improvement in results of the water treatment in such cases effected by the use of a coagulant is sufficient justification for the additional expense.

Cost of Power for Operation.—The total cost of the power necessary for operating these plants is not vastly different for the two types, except in special cases in which the larger pumping cost for the intermittent plant may amount to a considerable item of expense.

Cost of Labor.—In very large plants, say, 50,000 gal. per hour or more, the amount of labor required for the two types of plants is approximately the same, since in both cases the entire time of one man is usually devoted to the care and operation of the plant. In smaller plants, however, there is a marked difference in the amount of labor required. For plants ranging from those of very small size up to about 20,000 gal. per hour, the total time required in the case of the continuous softener

should not exceed about three hours; while in the case of the intermittent plants, practically the entire time of one man will be required.

This difference in the amount of labor involved is due, of course, to the fact that in the case of the continuous softener the chemical feeding tanks may be filled very quickly with enough of the reagents to treat water for a good many hours' supply; or in the case of the intermittent softener the succession of filling, treating, and emptying operation is necessarily so frequent that a man's time is pretty well occupied.

Comparison of Results Obtained

Assuming proper operation in both cases, properly treated water can be obtained from either type of apparatus. The particular field of usefulness of the intermittent type of softener has been held to be for waters of variable composition, such as those of rivers and of other sources of supply. The validity of this statement is not evident upon a careful examination of the method of operation of a typical intermittent softener, nor of the results obtained. The ideal way to handle water in an intermittent softener, of course, is to take a sample of the water shortly after it has been thoroughly mixed with chemicals, and from tests on this water determine what change, if any, is necessary in the treatment. If a change is found necessary, which could easily be the case with a water of changing composition, the tank of water would have to be held until the treatment was adjusted either by the addition and agitation of more chemicals, or by the waste of treated water to allow for dilution with enough raw water to compensate for the overtreatment. The loss of time involved here would so lessen the effective period of service of a tank that the number of tanks would have to be increased to provide for such contingencies. Observation of the actual operation of intermittent plants shows that as a rule the charge of one tank is based upon the chemical test made on the water of the previously treated tank; that is, the treatment of any particular tank is at least one tank behind any change in composition of the water.

In general, the human element would seem to play a greater part in the operation of an intermittent softener than in a continuous plant, since the number of man-made operations is considerably greater during the course of a day's operation.

(B) ECONOMIC VALUE OF LIME-SODA SOFTENING PRELIMINARY TO ZEOLITE SOFTENERS

The economic value of lime-soda softening preliminary to zeolite softening is dependent upon so many conditions that perhaps the best that any committee can do for the guidance of the general public in this respect is to point out the conditions which will affect the economic value of preliminary treatment so that these points will be given consideration when this question is decided.

Such preliminary treatment as the water requires for filtration purposes may be disregarded, for it is assumed that it is well understood that all

waters containing suspended matter must be satisfactorily filtered before delivery to a zeolite softener. Whether or not sedimentation must be provided ahead of the filters is purely a filtration problem. The water must be made crystal clear before delivery to a zeolite softener.

Consideration must be given to the following:

(1) **Direct Use to Which Softened Water Will Be Applied.**—If the softened water is to be delivered to evaporators the presence of a large amount of sodium carbonate will not necessarily be seriously objectionable. Likewise, the sodium carbonate is not objectionable if required to soften the make-up water of the circulating system when using a cooling pond, to prevent scale formation on the tubes of surface condensers.

Where zeolite-softened water is fed directly to the boilers the high sodium carbonate resulting from this treatment is objectionable for the following reasons:

(a) There is a tendency to cause foaming and priming of boilers because of high alkalinity concentrations in the boilers. To prevent priming the boilers must be blown down sufficiently, the amount of water depending upon the type of boilers, the rate at which boilers are fired, and other operating conditions.

The question in this respect that must be considered is "How much less will the boilers need to be blown down to prevent priming if the water is given preliminary softening before zeolite softening than if the zeolite softener is used alone?" Clearly the blow-down losses for boilers operated at high ratings will exceed the losses for comparatively small boiler plants where customarily boilers are not much overloaded. For small boiler plants unquestionably zeolite softeners have been used with satisfaction without pretreatment, whereas for larger plants with boilers operated at considerable overload pretreatment would be necessary before zeolite softening.

(b) The probable effect of the sodium carbonate on caustic embrittlement of boiler plate is not well understood. The May, 1925, issue of *Mechanical Engineering* gave the suggested rules for care of power boilers which contained the recommendation that for working pressures of 150 lb. and under the alkalinity in terms of sodium carbonate should not exceed the sodium sulphate; for working pressures over 150 lb. and under 250 lb. alkalinity not to exceed one-half the sodium sulphate; for working pressures of 250 lb. and higher, alkalinity not to exceed one-third the sodium sulphate.

Many waters treated by zeolite softeners will give a ratio of sodium carbonate to sodium sulphate unfavorable to the above recommendations of the A.S.M.E. Boiler Code Committee. To determine the economic value of pretreatment from the standpoint of embrittlement it is not only sufficient to give consideration to the amount of temporary hardness in the raw water, but the amount of sulphates present must also receive consideration. This will, furthermore, obviously be dependent upon the boiler pressure. The higher the boiler pressure the more necessary the pretreatment for a given water supply.

The after-treatment of a zeolite-softened water with sulphuric and phosphoric acid is now being done in a number of commercial plants to lower its alkalinity.

(2) **Cost of Pretreatment.**—The cost for additional equipment for pretreatment is considerably greater per thousand gallons water treated for small capacities than large. Consequently it would follow that pretreatment might prove economical for comparatively large installations, whereas it might not be economical for small capacities. The comparative costs must therefore be considered.

Again, it is obvious that the additional cost of equipment for pretreatment to lower the carbonate hardness will be considerably less if in any event the water requires, filtration. Particularly is this true if the water requires sedimentation ahead of the filters. If before delivering water to the zeolite softener the water must be filtered and also settled, the additional cost for pretreatment of the water for lowering the hardness will be much less than if a city supply of well water that does not require filtration, were available.

The cost of chemicals for removal of the temporary hardness is ordinarily less than the cost of salt, considering that for calcium carbonate hardness more than 4 lb. of salt must be used for the equivalent accomplished by 1 lb. of hydrated lime, for precipitation of magnesium carbonate 2 lb. of salt are required for the equivalent of 1 lb. of hydrated lime. The costs of salt and lime vary quite considerably, depending upon the proximity to the source of salt and hydrated lime. Freight rates have an important bearing on these costs.

Comparative cost of pretreatment must also be considered with an after-treatment of a zeolite-softened water with sulphuric and phosphoric acid which is now being done in a number of commercial plants to lower the alkalinity of zeolite-softened water.

This question must also be considered in comparison with the cost of equipment for softening the water without introducing large amounts of sodium carbonate as may be obtained by hot-process and cold-process lime and soda softeners.

From a study of the above it is evident that the question of whether or not pretreatment is advisable becomes complicated if an attempt is made to derive a formula applicable to all conditions, whereas a consideration of all the above factors generally becomes very simple for any plant if all the conditions are known. It is therefore believed that the best that this committee can do is to point out the influencing factors, the most important of which have been mentioned above.

(C) ECONOMIC VALUE OF LIME-SODA SOFTENING PRELIMINARY TO EVAPORATORS

The economic value of lime-soda softening preliminary to evaporators is dependent upon so many conditions that a number of the recommendations made for pretreatment to zeolite softeners in our previous report will be applicable to pretreatment for evaporators.

A survey of the central stations using evaporators indicates that waters containing 10 grains or more "total hardness" are being given pretreatment, and that waters containing 6 and 7 grains total hardness are being evaporated without apparently giving serious trouble.

A total of 55 questionnaires were sent out to central stations throughout the country, using evaporators, requesting data relative to operating conditions, cleaning, nature of water, etc. The results of this survey are classified as follows:

Class 1—18 questionnaires have not been acknowledged. (32.7 per cent.) A second attempt was made to obtain data from these companies but apparently without success. The possible explanation for this may be that questionnaires were addressed to holding companies as well as to the individual company.

Class 2—13 users acknowledged the questionnaire, but for various reasons have not furnished information. (23.6 per cent.) These were returned not filled out for various reasons: equipment not yet in service; equipment in stand-by plants; equipment has not been in service long enough to accumulate data; no available data, etc.

Class 3—24 users returned the questionnaire filled out as requested. (43.7 per cent.) These questionnaires returned containing the requested data have been carefully analyzed, and from this information our report has been prepared.

The analysis of the questionnaires indicates that 42 per cent of the users regard pretreatment warranted on account of scale, but 58 per cent of the users regard pretreatment not warranted. Of the 42 per cent who regard pretreatment warranted, 21 per cent use external softeners, 12.6 per cent use internal treatment, but do not regard it satisfactory, and 8.4 per cent give no treatment but recommend it.

A careful examination of the chemical analysis of the waters used by the above installations indicates that with the exception of one water all have a "total hardness" of 10 grains or higher. The one exception has a "total hardness" of only 6 grains. Of the 58 per cent who regard pretreatment *not* warranted, 53.9 per cent use water less than 6 grains "total hardness," and 4.1 per cent use water of 7 grains "total hardness."

One installation of the above 58 per cent treats the water with sulphuric acid to give a more favorable relation of sodium sulphate to sodium carbonate on account of water naturally containing 6 grains of sodium carbonate per gallon. This is done because evaporator gives off some moisture, and soluble salts are formed in the distillate.

It would be a difficult matter to try to indicate the average saving in dollars and cents to be obtained by pretreatment ahead of evaporators as there are so many variables to be considered, i.e., the amount of water evaporated between cleanings; the condition of the water; irregular cleaning periods ranging from one week to one year; reduction in capacity varying from 2 to 50 per cent, and cost of cleaning varying from $20 to $600.

The cost of additional equipment for pretreatment might be considerably greater per thousand gallons of water treated for small capacities than for large capacities; consequently it would follow that pretreatment would prove economical for comparatively large installations, whereas it would not be economical for small capacities.

The most significant facts brought out by this investigation are that waters containing 10 grains or more "total hardness" are being given pretreatment, and that waters containing 6 and 7 grains "total hardness" are being evaporated without apparently giving serious trouble.

PRESENT KNOWLEDGE OF FOAMING AND PRIMING OF BOILER WATER, WITH SUGGESTIONS FOR RESEARCH

Progress Report on Zeolite Softeners, Internal Treatment, Priming and Foaming, and Electrolytic Scale Prevention

In 1863 Stromeyer in his work on marine boilers wrote that information on the subject of priming was "almost non-existent." Eighteen years later Stabler evidently felt that little information had been added, for he began his section on foaming and priming with the statement that they "are probably the least understood of boiler phenomena." At the present day, sixteen years later, Stabler's statement still holds. The only modification that suggests itself would be to leave out the word "probably."

Phenomena to Which the Names "Foaming" and "Priming" Have Been Applied

Much effort has been expended in the past in trying to define "priming" and "foaming." A search of the literature shows utter confusion in the use of these terms. Some authors employ them interchangeably. Some call a foam on the surface "priming," and others call violent ebullition "foaming." Indeed, it can be said that a reader of any book or paper will not know what is meant unless the writer defines his terms.

Fortunately the question can be approached another way. Instead of seeking the meaning of the terms one can differentiate and describe the phenomena to which these various names have been applied. From this standpoint, then, an examination of boiler-water papers shows that one or more of three fairly distinct mental pictures of phenomena inside the boiler were in the minds of writers when they used the terms "foaming" and "priming."

(1) The formation of foam on the surface of the water. This foam may range in thickness from a layer barely covering the surface to a mass that fills the steam space above the water. In the latter case the liquid films around the bubbles would be drawn into the steam pipe and wet steam would result.

(2) Another phenomenon evidently in the minds of certain writers is merely rapid ebullition with the consequent projection of droplets or even slugs of water into the steam pipe. This could happen without the appearance of foam as it is described above.

(3) A third situation partakes both of the properties and appearance of foam and of violent ebullition. The boiling is of such a character that the whole mass of water from the bottom up is full of fine steam bubbles, with the consequence that the interior of the boiler is filled and of course much water passes out with the steam.

It should be emphasized, perhaps, that the three situations pictured above are not necessarily descriptions based upon actual observations of steam boilers in operation. If such observations have been made the author

has failed to find the record of them. They are to be looked upon more as reasonable suppositions by men of experience with steam boilers, and who have undoubtedly observed analogous situations in glass flasks or open metal vessels. Moreover, some writers evidently have no picture in mind of what goes on inside the boiler. They simply use the terms as meaning any entrainment of water by the steam.

Systematic research may show that a fourth phenomenon, namely, the manner in which bubbles break on the surface of the water in the boiler, should also be considered, at least as one of the causes of wet steam. This idea was first suggested by Dr. R. E. Hall, who used the phrase "smoothness of boiling."

It is well known that a bubble breaking on the surface of a liquid projects a droplet of the liquid to a height of several inches. This phenomenon has never been studied so that nothing is known of its mechanism or of any way of controlling it. It seems reasonable to suppose that a continual projection of droplets of water into the steam space would be a large factor—perhaps the determining factor—in causing wet steam when other conditions were normal, that is, when there was no foaming or priming.

The confusion of terms that exists is deplorable, and now that an official committee representing a number of interested engineering societies is at work on this feature of boiler-water behavior, one of its first duties should be the clarification of the nomenclature. However, before permanent definitions are formulated there should be an extensive series of accurate observations made, if possible, on actual steam boilers, and failing that, on experimental boilers, in order to determine with some precision the various causes for the entry of water from the boiler into the steam. Appropriate names can then be found for the phenomena.

CAUSES OF FOAMING AND PRIMING

Physical.—The causes of foaming and priming as given in boiler-water papers fall under two general heads, physical and chemical. Among the physical causes the design and operation of the boiler are outstanding. The more complex the interior—that is, the more of a maze of tubes, staybolts, etc., there is in the boiler—the more likely is it to foam (prime). It is also evident that, other conditions being the same, the smaller the steam space above the water, the more likely is water to be carried out. If the boiler is moved about rapidly while in use, as is the case with railroad and marine boilers, the extra agitation will promote foaming.

Violent ebullition for a few seconds may result from the sudden evolution of steam following a period of superheating of the water analogous to the familiar "bumping" of liquids in the laboratory. A similar effect would be produced by the loosening of a sheet of scale, which would thus bring water into contact with almost redhot metal. The sudden introduction of solid matter, entering with the feedwater or produced by the loosening of scale, also causes a violent ebullition for a few seconds,

and a rapid opening of the steam valve by causing a momentary lowering of the pressure has the same effect.

There is some difference of opinion as to the relation of steam pressure to foaming, but the majority seem to hold that high-pressure boilers foam less than low-pressure ones. Such a statement seems logical because a given weight of steam occupies less space the higher the pressure it is under.

Chemical.—The available information about the chemical causes of foaming may be classified under (1) substances that cause foaming, and (2) physico-chemical explanations of the phenomenon. The offending substances are listed under such indefinite terms as "organic matter," "impurities," "oily matter," "soap and soapy substances," "saline matter," "alkalis," and "suspended solids." Sodium salts seem to be the only definite chemical substances to which foaming and priming are generally attributed, but the author has not been able to find a record of any experiments which show that sodium salts alone are the cause of the trouble. The belief has unquestionably originated from the fact that in the great majority of waters sodium salts are the only ones that concentrate in the boiler. Others that are present in any quantity, such as calcium and magnesium compounds, precipitate for the most part.

Next to sodium salts finely divided solid matter is held responsible for foaming and priming, and some go so far as to assert that solids are the only cause, barring, of course, occasional cases of soap or peculiar forms of organic matter in the water. Here again, however, the record of experimental evidence in favor of this view is lacking.

In 1924 the author, acting on a hint from Bancroft, succeeded in harmonizing the conflicting statements concerning the effect of sodium salts and solid matter. An extensive series of laboratory experiments showed that sodium salts alone or finely divided solids alone did not cause a true foam, but that when both were in the water in sufficient concentration foaming resulted; that is, a true foam or froth several inches thick was produced on the surface of the water. The explanation of this is given below.

THE PHYSICO-CHEMICAL THEORY OF FOAMING

Wherever the word "foam" or one of its derivatives is used in this section, it refers to a true froth or foam as described in No. 1 above.

It must be said at the start that there is as yet no comprehensive physico-chemical theory of foams. This fact, perhaps more than any other, retards the progress of research in this field. The statement frequently found that foaming is caused by lowering the surface tension of a liquid seems merely to express a coincidence. While it is true that the foamiest liquids (for example, soap and saponin solutions) have low surface tensions, it is also true that pronounced foaming can be produced by conditions that raise the surface tension. Water solutions of inorganic substances—sodium salts, for example—foam readily if the films are stabilized by finely divided solid matter.

Furthermore there is no quantitative relation between the lowering or raising of the surface tension of a liquid and the foam producing power of the resulting solution. Water solutions of soap and saponin, for instance, may be equally foamy, the saponin even foamier than the soap, and yet the surface tension of the saponin solution will be much higher than that of the soap.

This question of the lack of relation between surface tension and foaming is discussed at length by W. Ostwald and A. Steiner, who give many literature citations. The immediate relation of the problem to boiler water is touched upon by Millard and Mattson, who show that what they call "priming" is in no way related to surface tension. Though these investigators do not distinguish between true foam and other phenomena, the description of some of their experiments leads one to think that foam should have been present.

About all that can be said is that pure liquids do not foam. Something must be present of such a nature that its concentration in the surface differs from that in the mass of the liquid. This interesting situation is quite common and can be shown by laboratory experiments. If, for example, a mass of soap bubbles is collapsed the resulting liquid will be found to contain more soap per unit volume than did the original solution from which the bubbles were produced. Whether there is more or less of the added substance in the surface than in the interior of the liquid seems to make no difference. Either way, the surface layer differs from the rest of the liquid and thus makes possible a separation of films from the surface. This separation of films is the necessary condition for the formation of foams. There is, however, another condition which, if not theoretically necessary is practically so, namely, the stabilization of the films. Most bubbles burst in the moment of their formation and therefore cannot form a foam. The films of a true foam must have a certain structural strength and period of existence. This is given by the viscosity of the film itself, as in the case of soap bubbles, or by the addition of finely divided solid matter which imparts the necessary viscosity, as in the case of the foams of sodium salt solutions stabilized by pulverized boiler scale.

No one has yet offered a plausible explanation of why a pure liquid does not foam and why a difference in concentration between surface and interior of a solution permits the separation of films. When a bubble generated in the interior of certain solutions rises to the surface it lifts a film; or when a ring composed of any solid that is wet by the liquid is applied with appropriate technique to the surface and lifted, a film is removed. What now determines the plane of separation of that film from the remainder of the liquid? The answer to that question would be the general theory of foaming.

The author believes that research on this fundamental problem should be directed to a study of the conditions which control the maximum *thickness* of films. Heretofore attention has been focused on their minimum *thinness*. Bancroft says, "I have not been able to find any statement as to

the maximum thickness of a soap-bubble film; but it is certainly not less than 1.4μ." This is many hundred times as thick as the layers of oriented molecules pictured to account for surface-tension phenomena. In general, it would be well to direct research to the relatively thick (1.0 ± mm.) layer at the surface of liquids. It is the sea of peculiar phenomena. Liebreich called it the "dead space in chemical reactions" because certain reactions at least fail to take place in it. Hannan refers to another phenomenon peculiar to this region, namely, the very rapid rate of sedimentation in it.

The relation of surface concentration to surface tension is in the sense that those substances which concentrate in the surface lower the surface tension, and those which recede from the surface increase the surface tension. It can also be shown, both theoretically and practically, that surface tension can be lowered to a much greater extent than it can be raised.

In general, organic substances lower the surface tension and inorganic ones raise it. There are, however, exceptions to this rule. Cane sugar, for example, slightly increases the surface tension of water and hydrochloric acid slightly lowers it.

APPLICATION OF THEORY TO BOILER WATER

On applying these principles to boiler water, it can be said that the fundamental condition of foaming is the presence of substances which concentrate either in the surface or in the mass of the water. If, however, these substances do not at the same time have the property of making the films around the bubbles stable, there will be no foam in a practical sense, because the life of the bubbles will be too short—they will burst a moment after forming. It is necessary, then, to distinguish carefully between the two conditions for the formation of foam—(1) the presence of something which, by modifying the surface of the water, makes possible the formation of bubbles, and (2) the presence of something which by imparting viscosity to the films will stabilize them—that is, prevent them from bursting immediately after forming. This necessary viscosity can, of course, be produced by the same substance which changes the surface. Soap, for example, is such a substance, and an occasional water is found in which the organic matter present has this property, either as it enters the boiler or after modification by the action of the superheated water. In the average boiler water, however, the change in the surface is brought about by dissolved sodium salts and the stabilization of the foam by finely divided solid matter. The presence of either one without the other is not sufficient to cause foaming.

The action of the particles of solids in stabilizing the foam appears to be purely mechanical. Edser, in a paper on ore flotation, pictures the situation as follows:

> Imagine a number of bubbles in the interior of a liquid, each bubble being coated with mineral particles. When these coated bubbles come into contact after rising through the liquid, the walls of each cell will consist of numerous solid particles held together by films of liquid.

In flotation the solid particles are frequently the only stabilizing agent present. It must, of course, be emphasized that to stabilize a boiler-water foam as well as that of a flotation process the solids must have the property of adhering to (being absorbed on) the films. Flotation as a method of separation would be impossible if solids did not behave differently in this respect and, it might be added, boiler foaming would be a rare occurrence were it not for the unfortunate circumstance that the solids usually present in a boiler have the property of adhering to the films around the steam bubbles.

Whether there is a manifest difference in the stabilizing effects of the different types of boiler scale has not yet been determined. Work now in progress in the author's laboratory suggests at least that this point should be investigated.

Other things being equal, the stabilizing effect increases as the size of the solid particles decreases. It is interesting, however, to note that particles so large that none will pass through a forty-mesh sieve can be seen adhering to the steam bubbles.

Koyl gives the presence of finely divided solids as the cause of the phenomenon described above under (3), but merely states that each particle becomes a nucleus from which a stream of steam bubbles rises. It would not be too far-fetched to assume that the particles that act in this way have entrained minute bubbles of air, or perhaps of carbon dioxide, which would then serve as permanent gas-phase surfaces at which steam bubbles would form. The stabilizing effect of the finely divided solid matter would tend to hold such steam bubbles intact—that is, prevent them from coalescing. In this way the mass of the water would become filled with bubbles, as Koyl describes.

In the author's previously mentioned paper a large number of laboratory experiments in glass flasks are described. This experimental evidence is too long to reproduce here, but is referred to because it furnished the confirmation of the theories advanced and which are given above. There is also another reason for referring to it. Ordinarily, laboratory experiments offer an unsafe guide for large-scale industrial operations, so that it is worth while in this case to record that the author has received additional evidence in the shape of a number of letters from persons of practical experience with steam boilers. These letters uniformly uphold the general conclusions of the paper, so that, in a way at least, it can be said that these laboratory experiments have been confirmed in practice.

ORGANIC MATTER AS A CAUSE OF FOAMING

Practically nothing is recorded concerning causes of foaming other than those mentioned above. The author has received two private communications to the effect that excelsior used as a filter in a water softener caused foaming during the first few days it was in use, after which the effect disappeared. This would mean of course that the water dissolved out certain organic materials that caused the trouble. Another communica-

tion cited the organic matter in certain of the highly colored surface waters of Florida as a cause of foaming. It would be interesting to know whether such colored waters from other parts of the country have the same effect, for example, those from New England. The question of the behavior of these waters, if at the same time they contain sodium salts and finely divided solids, is one that has not yet been studied.

TESTING WATER TO DETERMINE WHETHER IT WILL FOAM

A practical question naturally arises, namely, what chemical or physical tests can be made on a boiler water in order to determine whether it will foam? This point has never been thoroughly studied. Boiler-water chemists would determine the sodium-salt concentration and base their conclusions on the result. Stabler in his famous paper, giving equations by which the behavior of a water can be calculated, includes one on foaming which gives what he calls the "foaming coefficient." It is nothing more than an approximate value for the sodium and potassium salts in the water, and obviously would not apply unless finely divided solids were also present. If sodium salts and suspended solids were both measured a very good guess could be made as to the foaming susceptibility of the water. Unfortunately, however, it would not be safe to reason in the converse way, because some waters that are very low in sodium salts and suspended solids nevertheless will foam.

A foam test is still to be devised. Some preliminary work in the author's laboratory suggests the possibility of developing something practical from so simple an operation as blowing air into the water to be tested. If the air enters in very fine bubbles, as when blown, through a porous septum, a foam seems to be produced, even at room temperature, in all waters that foam on boiling, and vice versa. There is also the "membrane meter" of W. Ostwald and Steiner. These investigators found that when the level of a liquid in a capillary tube is raised or lowered the rate at which the liquid surface returns to its original position is inversely proportional to the foaming susceptibility of the liquid. The original paper must be consulted for the details of the experiment.

In applying these or any other test to a boiler, however, one must not forget that the raw water and the same water after it has been subjected to the high temperature of the interior of a modern steam boiler are by no means the same things. Nevertheless the development of a foam test is worth some research.

PRIMING

"Priming" as used in this section has a special meaning, namely, the projection of water into the steam space due merely to violent ebullition. In most cases, perhaps, it results from the ebullition of spasmodic violence accompanying the breakdown of a condition of superheating. Unpublished work done in the author's laboratory shows that in glass flasks at least it is far easier than has been supposed to heat water above its normal boiling point for the pressure of the moment. Indeed, the water may be

boiling, that is, copious bubbles of steam may be rising through it, and yet its temperature will be one or two degrees Fahrenheit above the normal boiling point. If now, with the water in this condition, it is subjected to a shock of some sort, like the introduction of a little solid matter or the addition of a slug of water from the outside, the superheated state breaks down and the stored-up energy is dissipated by a few moments of violent ebullition, the temperature of course falling to the normal. Everyone of course knows these facts about the superheating of liquids, but it is doubtful if many know how common the phenomenon is.

Other experiments were of the following nature: Flasks were so equipped that the steam from the boiling water in them escaped through a small orifice and therefore some inside pressure could be maintained and at the same time have the boiling proceed. If now a large valve in the stopper were opened the pressure of course dropped, the water was left at a temperature a degree or so above its normal boiling point for the lower pressure and consequently there was violent ebullition for a few seconds, so violent that large slugs of water were projected into the steam space.

If a similar situation can occur in a boiler when the steam valve is rapidly opened, the violent ebullition that will follow for a few seconds may easily throw slugs of waters into the steam line. The important point to note in these experiments is that this "priming" as it is called, can take place with pure water. It is independent of the conditions of film formation, etc., that are necessary for "foaming," in other words it is a separate phenomenon and therefore merits study as such.

The question naturally arises, what happens when the flasks are charged with sodium-salt solutions alone, suspended solids alone, or with both sodium salts and suspended solid matter? The answer is, that dissolved matter alone or suspended matter alone increases the "priming" only slightly but when both dissolved and suspended matter are present the priming is many fold that of pure water. The effect described in No. 3 above can be observed at times, that is, the water lifts by becoming a mass of steam bubbles. Owing to the fact that "priming" is so greatly increased in a water in which the conditions for the formation of stabilized films also exist, it is difficult to distinguish between "priming" and "foaming." In the situation just described it would be logical to say that the "foaming" was greatly increased during a few seconds by the "priming."

THE PROJECTION OF DROPLETS OF LIQUID BY BURSTING BUBBLES

So far as the author is aware, no studies have ever been made of the nature of evaporation from the standpoint of the projection of droplets of liquid into the steam space by the bursting of bubbles. Perhaps very slight additions of the right substances to a boiler water would cause its boiling to proceed with such "smoothness" that little or no water would be thrown up. The idea is fanciful, but nevertheless is worth at least a little laboratory experimentation.

REMEDIES FOR FOAMING AND PRIMING

The two outstanding methods of reducing foaming and priming are (1) reduction of the concentration of sodium salts, suspended solids, or other offending substances by blowing down the boiler, and (2) the introduction of castor oil into the boiler water. The first remedy is efficacious in about the extent to which the concentration of the offending substances in the water are reduced. Such a relation is so obvious that no theoretical discussion is needed. It is equally obvious that there is a heavy loss of energy in wasting water that has been heated to the temperature of the boiler, and therefore blowing down has severe limitations. Finally, the plan has no effect when the foam producing impurity is in the raw water.

Remedy No. 2, the use of castor oil, is perhaps the most interesting and effective treatment applied to industrial water. Its effect on the stabilized foams resulting from dissolved salts and suspended solids is like a touch of magic. A mere trace of this oil, less than 0.001 per cent by volume, causes the instant disappearance of the type of foam referred to above.

In actual practice castor oil is seldom or never used as such because it is not miscible with water and therefore difficult to apply in a uniform way. The general procedure is to prepare an anti-foam compound by emulsifying the oil with starch and other ingredients to give a mixture containing 14 to 15 per cent of oil. This will mix uniformly with a large quantity of even cold water so that the introduction of any desired amount into the boiler is easy.

On one of the Ohio railroads the rule is not to begin using anti-foam till the boilers begin to foam, which usually takes place when the concentration of dissolved solids reaches 3000 parts per million (175 grains per gallon). A pint of anti-foam compound, containing 16 per cent of castor oil, is then put into the tender tank, which holds 5000 gallons of water. This would mean a concentration of less than 4 parts per million (about 0.2 grain per gallon) of actual oil in the water, and yet by its use the boiler can be kept going till the concentration of dissolved solids reaches double the value given above.

This effect of castor oil in inhibiting foam is apparently confined to that type of foam in which the films are stabilized by suspended solid matter. "Apparently" is used advisedly because the matter has never been systematically studied. A few experiments in the author's laboratory seemed to show, for example, that the oil had no effect on a soap foam.

A few other oils also inhibit foam as castor oil does, but for one reason or another have never come into use. Bardwell found that pine-tar oil worked satisfactorily up to 140 lb. pressure, but not beyond. Incidentally, it might be remarked here that during the World War many experiments were probably made in search for substitutes for castor oil as an anti-foam. If this is true they ought to be recorded somewhere.

There is little or nothing on record concerning the prevention of foaming due to dissolved vegetable matter. French found that alum served to prevent the foaming caused by dissolved vegetable matter in a highly

colored Florida surface water. This is interesting because the generalization is perhaps warranted that such foam-producing substances can be rendered harmless by adsorbing them on precipitated aluminum hydroxide.

When the question of a physico-chemical theory of the destruction of foam by castor oil is raised, the answer must be, there is no theory. One may guess that the action is due to the destruction in some way of the stabilizing action of the suspended solids rather than to any effect on the liquid films. Perhaps the best way to get suggestions on this point is to study the data of ore flotation. Edser's paper in this connection is admirable.

FOAMING AND PRIMING AS A RESEARCH PROBLEM

Since the underlying purpose of this paper was to suggest points of attack in research work on the problem of foaming and priming of boiler water, it will be worth while now to classify the suggestions offered above. They fall naturally into two groups.

(I) Research with the object of finding the fundamental causes of foams and stabilized films in such water solutions as may occur in a steam boiler. This is a laboratory problem calling for measurements of surface tension, surface concentration, and viscosity, thickness of liquid films, angles of contact between solids and liquids, and long, patient experimentation with one combination of materials after another. Coincident with the above will be a line of experimentation with autoclaves or small experimental boilers.

This is the kind of work that is adapted to university surroundings in which the necessary scientific instruments, books, and journals are to be found.

(II) Research involving experiments with actual steam boilers under working conditions. This is preeminently the point at which the practical man comes in, and it is fortunate that the organization of the committees having this work in charge includes practical as well as theoretical men. The prospects for co-operation are fine.

There is of course no reason why these two groups of research should not mix in any proportion that circumstances may bring about, and it is certainly the wish of the author of this paper that they should be so mixed.

EMBRITTLEMENT OF STEEL

Progress Report on Embrittlement of Metals

The work of this committee has been confined to the consideration of the embrittlement of steels used in steam boilers. This subject has been receiving much study both here and abroad and many conflicting views have been submitted to the committee for consideration. These have been carefully considered and analyzed.

There are two schools of thought in regard to this subject. Certain engineers, after studying embrittlement from many angles, have been led to the conclusion that such embrittlement as occurs is inhibited by the presence of caustic in the waters in the boiler resulting from the occurrence of sodium carbonate in the feedwater. Other engineers also, after careful study of the phenomena, have concluded that other causes contribute to this type of failure and that the presence of caustic is not the controlling factor.

This report will summarize the evidence and reasoning of both schools of thought and will attempt thereby to give engineers a definite idea of the problems involved. The committee does not believe, in view of the data before it, that it is possible at the present time to reach any final conclusions regarding the cause and remedy of this trouble. Certain facts seem to be established and these will be presented. The committee also makes certain recommendations at the close of its report.

The following outstanding facts are presented as indicating the present status of knowledge of the phenomena:

(a) Embrittlement of boiler metal is an established fact and not a myth as believed by some engineers.

(b) The difficulty has not been encountered in any one section of the country although there are certain areas where failures of this kind have been more prevalent.

(c) In most cases where these failures have been experienced, the water has contained relatively high concentrations of carbonate, bicarbonate or hydrates of soda and these waters have been low in sulphates or chlorides of soda. Some cases of embrittlement of boiler metal have occurred, however, with waters where the concentration of sodium salts was low.

(d) Embrittlement is a function of excessive stresses in the metal, and the phenomenon apparently does not occur in the absence of stresses beyond the elastic limit for the metal.

(e) It has been shown experimentally that embrittlement of boiler steel may be produced at will in the presence of excessive amounts of hot caustic soda (20,000 grains per gallon) when the metal is under tension beyond the elastic limit. The phenomenon takes place usually by the combined action of high stress and high chemical concentration. These facts have been established by laboratory experiments but the element of time affecting the phenomenon has not been established.

(f) Laboratory experiments and experience in practice indicate that the embrittlement of the metal may be inhibited by maintaining a specific ratio between the sodium carbonates and sulphates present in the water.

(g) Failure of the metal progresses by intercrystalline fracture. In practically all cases there is no deformation of the grains.

(h) One investigator has determined that a similar phenomenon may be produced by calcium nitrate.

Various investigators are by no means in accord concerning the basic cause or causes of the phenomenon, and much discussion has arisen as a result of the two schools of thought. There are certain points, however, upon which there seems to be general agreement. These are as follows:

(a) Brittleness of boiler steel may occur in the presence of high concentration of caustic soda and result from straining the metal beyond the elastic limit.

(b) Failures of this kind are intercrystalline in character.

(c) The cracking of metal occurs in practically all cases along the line of the rivets and on the dry side of the plates.

Certain investigators believe that the brittleness of metal is affected by the absorption of cathodic hydrogen, and that the rapidity of the action is accelerated by stresses in the metal. This view has not received universal acceptance.

Still others hold that embrittlement is due to the presence of such impurities as iron sulphide at the grain boundaries, which are dissolved by the action of caustic soda or other chemicals.

Some engineers believe that embrittlement is due partly to certain inherent characteristics of the steel and partly to stresses from deformation and riveting in the process of manufacture augmented by the stress due to the working pressure in the boiler. Evidence has been submitted to confirm this view.

A Review of Investigations and Opinions on Embrittlement

As early as 1866 Graham made the interesting discovery that red-hot iron was penetrated by hydrogen and that a portion of the hydrogen was retained by the metal after it had cooled down. Caillet and Johnson arrived at a somewhat similar conclusion and demonstrated that hydrogen generated electrically was absorbed by iron at room temperatures. They showed further, however, that hydrogen in a gaseous form apparently had no effect upon the metal. In Johnson's work it was shown that soft iron became embrittled in contact with electrolytic hydrogen. It was further shown by Johnson that the treatment of the iron with acid prior to contact with the gaseous hydrogen, greatly accelerated the rate of embrittlement of the metal. It was reported by Thompson that fairly high concentrations of solutions of soda at boiling temperatures had no appreciable effect on the properties of soft iron. It was also shown by the same investigator that soft iron was much more seriously affected by boiling water. Somewhat similar results were obtained by T. S. Fuller. This investigator showed that the rate of absorption or penetration of hydrogen through a sample of elec-

trolyzed iron was practically the same with one per cent caustic soda as when tap water was used. W. D. Andrews reported the results of experiments in the Transactions of the Faraday Society, 1914, stating that strips of steel kept in concentrated sodium hydroxide solution at 212 deg. Fahr. for a period of from one to seven weeks were seriously embrittled. Hydrogen was evolved as the result of the action of the caustic soda. Most widely quoted experimental studies on this subject are those of S. W. Parr, published in the University of Illinois Bulletins in 1917 and by Parr and Straub in 1926. The conclusions reached by these investigators are as follows:

(a) Embrittlement in boiler plate is caused by the combined action of stress and chemical attack. The stresses are inherent in the construction and in the operation of the boiler, while the chemical attack is caused by sodium hydroxide in the boiler water.

(b) Certain methods of water treatment tend to convert some safe waters into the characteristic type of water which produces embrittlement.

(c) The presence of sodium sulphate in the feedwater and undecomposed sodium carbonate in the boiler water tends to retard the embrittling effect of carbonate waters, and if these are present in proper proportions they will stop it entirely.

(d) Methods for introducing sulphates in boiler waters have been worked out to the point of practical application.

R. S. Williams and V. O. Homerberg report in the Transactions of American Society for Steel Treating, April, 1924, the results of their experimental studies carried on at the Massachusetts Institute of Technology. The conclusions of these investigators are as follows:

(a) During the crystallization of steel, the impurities, to a considerable extent, are rejected to the grain boundaries.

(b) The oxides and sulphides are two of the prime factors in caustic embrittlement.

(c) The oxides are reduced under the influence of cathodic hydrogen.

(d) The sulphides are removed due to the action of hot caustic soda solutions.

(e) The removal of the sulphides produces a surface condition favorable to progressive corrosion.

(f) Assuming that progressive corrosion starts with the removal of the sulphides, the corrosion will be greatly accelerated if the material is stressed. Furthermore, when the steel is under tension there is a tendency for the matrix to pull away from the inclusions at the grain boundaries and in this manner to produce small capillaries into which the corroding solution can penetrate.

(g) In stressed areas containing oxides, the volume increase, due to the reaction with cathodic hydrogen, may produce stresses which, added to those initially present, may cause cracking.

(h) It seems evident that hydrogen acts in three ways to produce embrittlement: first, the temporary brittleness caused by absorbed hydrogen (as in acid pickling), second, it acts to reduce oxides, and third, its effect due to the change in volume at the grain boundaries, resulting because of the

production of water. This latter volume increase would create a stress which, added to those originally present, may cause cracking, especially at those points where these stresses are at a maximum.

The 1922 Report of the Prime Movers Committee, National Electric Light Association, on Treatment of Feed Water, in discussing this phenomenon, gives the general characteristics present in the embrittlement of boiler plate as follows:

(a) Occurrences ordinarily limited to the joints of the boiler.

(b) Occurrence only in parts of the boilers reached by the water. This is most noticeable in girth joints, as up to the place reached by the water (not necessarily the normal water line), cracking is found, and beyond that point the plate is unimpaired.

(c) Occurrence in the various members of the joint; that is, in the rivets as well as the plates, in both plates of a lap joint, or in plates and straps of butt joints.

(d) Occurrence in rolled plates, cast steel or cast iron, according to the construction of the boiler.

(e) When a plate is cracked, the line of the crack on the surface of the plate in contact with the surface of another plate is longer than the line of the crack on the other surface of the same plate (i. e., embrittlement starts at the surfaces in contact).

(f) Extreme irregularity of the cracks with sharp changes of direction; paralleling without any marked tendency to join; in other words, the exact position of a crack is not determined by the stress due to the boiler pressure, though the general area affected may be.

(g) Brittleness of the material under shock and fatigue, with very little indication of brittleness under static tests, and marked localization of the embrittlement to the joint area.

(h) Loss of embrittlement (not necessarily total) with time when the boiler is removed from service, coupled with a marked degree of removal of embrittlement by heating at temperatures far below those required for ordinary annealing.

(i) A plentiful deposit of a black, powdery substance on the affected surface which on analysis is principally an iron oxide.

Since the location of cracking of this sort is selective with respect to the parts of the seams reached by the water of the boiler, reference should be made to the feed conditions and apparently with the following conditions in mind:

(a) Solubility will be of prime importance for the reason that a highly soluble substance may be present in heavy concentration without depositing anything on the metal to mechanically protect it.

(b) These substances should not attack the metal in the concentration in which they usually occur in a boiler, but should attack the metal in the higher concentration that can build up in restricted areas like the boiler joints.

(c) Acids can be eliminated from consideration, as they attack the entire metal surface at any concentration that could occur in boiler practice.

(d) Substances of high specific conductivity would increase the corrosive effects resulting from potential differences in the boiler structure.

(e) Substances such as calcium and magnesium carbonates, calcium sulphate, etc., being incrusting salts and of low specific conductivity, may be eliminated from consideration for either reason alone.

The soluble salts generally found in practice are given in the following table, Column "A" showing solubility in grams per 100 cc. of water at 100 deg. cent., Column "B" showing equivalent conductivity at 18 deg. cent.:

	"A" Solubility	*"B" Conductivity*
Sodium Chloride	39.12	92.0
Magnesium Chloride	73.0	98.1 (½ $MgCl_2$)
Calcium Chloride	159.0	88.2 (½ $CaCl_2$)
Sodium Sulphate	42.5	78.4
Magnesium Sulphate	73.8	76.1 (½ MgS_4)
Sodium Carbonate	45.5	72.9
Sodium Hydroxide	339.0	203.4
Potassium Hydroxide	178.0	228.0

NOTE: Potassium hydroxide, while of most exceptional occurrence, is included on account of the values of its constants as compared with sodium hydroxide.

From this table, sodium hydroxide has the greatest index of solubility and conductivity. Sodium chloride is relatively low in both solubility and conductivity, and by itself is not known to be corrosive under boiler temperatures at any concentration. Magnesium chloride and calcium chloride, while higher than sodium chloride in solubility and conductivity, have hydroxides that are very low in solubility, and corrosion from these substances occurs even at low concentration on all exposed surfaces. Hydrolysis of sodium carbonate is very considerable under boiler temperature, and within the range of usual boiler concentration in its effect it may be regarded as though it were sodium hydroxide. Sodium sulphate will ordinarily occur in boilers as the result of the initial use of sodium carbonate, so that for all of the foregoing reasons sodium hydroxide should (*a priori*) be considered as the most probable cause of the trouble. It is to be noted also that sodium hydroxide is only very slightly corrosive at boiler temperatures in solution strengths such as occur in the main body of the water in the boiler, but is actually highly corrosive in the stronger solutions that can occur in the joints.

F. B. Porter has drawn the following conclusions from the results of his studies:

> "At the University of Illinois, boilers had been operated intermittently for twelve years at 100 lb. pressure on the soft alkaline water without trouble. Three years' operation at 140 lb. pressure put four drums out of service, and we judge that there were four drums that withstood this same operation that were still unaffected. There is a large number of boilers at Fort Worth, Dallas, Waco, McKinney, Houston, Baton Rouge, Louisiana, and other points that have been operating on soft, alkaline water on pressures from 150 to 210 lb. that have never shown indications of embrittle-

ment. The Trinity sands water in Texas contains enough sulphates to give a sulphate ratio of something like three of sulphates to one of alkalinity, but the other artesian waters used at the plants just mentioned have much less sulphates, some of them only a very small amount. In one plant at Dallas, two plants out of four at Houston, and at one Waco plant an occasional drum has been lost through embrittlement, and in practically every case other drums which have seen the same service with the same water are still in operation, and other plants using the same water have never been affected.

"The question of the contributing causes of this peculiar type of embrittlement is important in suggesting remedies and in adjusting a settlement on installations on which renewals are required. This trouble occurs often within six months to three years of the time the boilers are put in service. The cracking occurs in regions of little stress. The actual stress in boiler operation in butt-strap seams is small compared with other sections of the drum. The stresses in the metal set up in the fabrication of the drum in the area adjacent to the rivets may be high. It is a difficult question to decide whether boiler-water leakage into the seams evaporates and produces high concentration and starts embrittlement, or whether the embrittlement and cracking start and the leaks promptly result therefrom. If the leaky condition comes first, it probably does not make very much difference what the concentration of the boiler water is, for the reason that a concentration even to the solid can rapidly occur in the seam as soon as the leak starts.

"The impression has been general that it is only overtreated, softened waters that would be likely to cause embrittlement. A recent case of embrittlement where zeolite-treated water only had been used would indicate that any softened water may furnish one of the requisite causes for embrittlement. The mention above of pressures obtaining in boilers and intermittent operation as compared with continuous operation, leads us to make the general observation that we believe that higher pressures and more continuous operation tend to increase the likelihood of embrittlement taking place, but this is as strong as this statement can be made, for some boilers operating under the same pressure and on the same water may be affected and some of them not. One hundred and forty pounds at the University of Illinois, which caused the loss of four drums, is considered a very low water pressure on large plants today.

"In conclusion, it seems at the present time that the only explanation of caustic embrittlement that will account for this condition being present in some drums of some plants and absent in other drums of these same plants, and absent in all the drums of other plants, using the same waters and the same type of waters, is that embrittlement is due to overstrained or dirty steel and causticity in contact with same."

Mr. McAdam, of the U. S. Naval Engineering Experiment Station, in a discussion of Professor Parr's paper at the 1926 meeting of the A.S.T.M., reported that he produced intercrystalline cracks in specimens subjected to fatigue tests when he cooled them during the test by directing a jet of water against the specimens.

Mr. Patterson of the Solvay Process Company in a discussion of Professor Parr's paper (loc. cit.), pointed out that caustic soda cannot concentrate very appreciably within the interstices of a seam as long as the seam

is tight, since the boiling temperature of a more concentrated solution is higher than that of a more dilute solution, so that as soon as a concentration of the caustic soda solution within the seam rises above that of the main body of water in the boiler, further concentration in the seam stops, since no further evaporation will take place. Therefore it will be impossible to concentrate the solution within the seam to the degree found active by Professor Parr, as long as the seam does not leak. Mr. Patterson has directed attention to the possibility of oxygen in the water as a possible offender accelerating embrittlement.

Mr. Applebaum of the Permutit Company has quoted the work of Mr. Jones:

"In a fresh solution, stressed steel cracked in a few days, but after the solution had been in use for some time the steel became coated with a black deposit of oxide and cracking was inhibited. This is not solely due to the alteration of surface of the steel since the solution now fails to crack fresh similar specimens which are introduced and which themselves become coated much more quickly than the original specimens. A deposit consisting of magnetic oxide and some carbonaceous matter accumulated at the bottom of the vessel. The inhibiting effect of the presence of oxide lends support to the view that cracking is brought about through the agency of hydrogen."

As a result of the experience and extensive experimental work of the Babcock and Wilcox Company, the following conclusions have been drawn by the company concerning this phenomenon and are reported in the 1925-26 Report of the Prime Movers Committee, N.E.L.A., on Treatment of Feed Water.

Certain characteristics of this cracking are as follows:

1. The cracks all occur below the water level.

2. In at least one of these plants, cracking of boiler drums has continued over a period of at least twelve years. In some cases, replacement drums cracked in a shorter period of time, notwithstanding special care in manufacture.

3. All of these cracks have occurred in seams under tension, having factors of safety, as normally calculated, from five to approximately ten.

4. Examination of the type of plate showing cracks has definitely shown that this cracking occurs in plates having practically perfect chemical and physical characteristics, as well as in plates which may not have as good characteristics.

5. These cracks have developed in cast steel, steel boiler plate and the most perfect rivet steel.

The characteristics of the cracks themselves in general are:

(a) They do not follow the line of maximum stress.

(b) While in general they run from one rivet hole to another, they run more often in entirely different planes, so there will be a crack from one rivet hole passing parallel to a crack from another rivet hole.

(c) They frequently run from each of two adjacent rivets past each other for at least half their length without joining, or they even cross the

full ligament from rivet to rivet without joining, leaving little islands of plate.

(d) They are irregular in direction when fully developed, having numerous sharp angles, and the final directions of the cracks is sometimes 90 deg. from that at their beginning.

(e) They never extend into the body of the plate beyond the lap of the plate.

(f) They sometimes occur on the solid plate of the seam and do not connect with the rivet holes.

(g) The cracks are not accompanied by elongation of the plate.

(h) Photomicrographs of these cracks indicate that they are intercrystalline.

(i) The cracks start on what is usually termed the "dry" face of the joints.

(j) As stated before, the cracks all occur below the water level of the boiler.

The 1925-26 report of the Prime Movers Committee, National Electric Light Association, on Treatment of Feed Water, contains a statement by the Permutit Company in which they summarize the factors that enter the problem, as follows:

"In our opinion there are four factors which must be considered in tracing the origin of cracks in boilers:

(a) The quality of the steel.

(b) The stresses either existing in the plate before fabrication, or introduced during fabrication, operation and repair, in addition to the calculated working stresses.

(c) The temperature to which the steel is exposed when under the total stress and the period of time during which the total stress is acting.

(d) The composition of the feedwater as well as the boiler salines."

A number of interesting comments have been received, some of which are reported herewith. The president of a firm manufacturing chemical machinery in a letter to the chairman states as follows:

"In the manufacture of caustic soda we find that the eventual failure of what is known as a caustic soda pot is probably due to the continued heating and cooling of the cast-iron pot rather than to definite caustic or chemical action. It is true that we do have some of this caustic or chemical action, but the industry seems to agree fairly well that the reason for the final destruction of caustic soda pots is that continuous heating and cooling of the vessel itself bears the greatest burden of the failure of the casting."

A leading consulting engineer in a letter to the chairman states:

"The full nature of conditions tending to cause caustic embrittlement is far from definitely determined. The evidence while pointing to existence of caustic in solution as probably the most frequent cause, would indicate, however, that caustic by no means occupies a unique position in that respect."

A prominent chemical engineer writes as follows:

> "I fail to find any direct tie-up between the character of the water and embrittlement. Such tie-up as does exist is based very

largely on 'hunches,' and not on any real data. That is, we know that certain of the water analyzed is poor water for boilers. We deduce, therefore, that this water will produce caustic embrittlement. We examine the boilers and we find cracks and fractures. The boiler even in certain sections may manifest considerable brittleness. We put the two things together and reach the conclusion that the boiler feedwater has been responsible for the cracks and other failures, through the action of caustic embrittlement. Such reasoning may be correct. It does, however, lack the continuity of proof, which we, as engineers, should demand."

An interesting case of embrittlement in a pressure vessel normally containing hot caustic soda in rather high concentrations, was recently called to the attention of the chairman. This case was very thoroughly investigated and the conclusion reached that the failure was apparently due to the structure of the plate itself at the time it was fabricated. Microscopic examination showed an almost perfect Widmanstaetten structure (a structure usually formed in cast steel) in the cross-section of the metal. In view of the inherent weakness of this structure, it is doubtful whether the caustic had any influence in causing the failure of the shell.

A leading British metallurgist who has devoted much study to this subject and from whom the committee requested a statement, has written the chairman in a private communication as follows:

"I do not know of any recent publication in this country bearing on the matter, but I have followed with interest what has been done in America and Germany. With regard to Professors Parr and Straub's paper, I have read it with very great interest and appreciation. While I find some difficulty in believing that a concentration as high as their experiments suggest, can ever be produced in a boiler, even in the fissures or seams, and while I also think that a stress exceeding the yield point can only be caused by the existence of severe local stresses due to excessive riveting pressure, etc., I yet feel that their present work has put the matter on a sounder basis than formerly. Their experiments appear to me to establish the fact that caustic soda when sufficiently concentrated can act as an accelerator of cracking in heavily stressed steel. Whether this can be regarded as by any means a full explanation of what occurs in boiler practice, is quite another matter and remains to be established by further work. The only light that I can throw on the whole question is that, so far our experiments—made with a view to producing fracture under prolonged loading in mild steel stressed to various intensities at a temperature of 300 deg. cent. in air—have failed to produce fracture even after a number of years' exposure. This experiment certainly suggests that some subsidiary agency of a corrosive nature is necessary to produce failure in a reasonable time, although it is quite possible that the particular sample of steel which I employed was not one subject to intercrystalline fracture under prolonged loading. There is to my mind no doubt at all that the nature and condition of the steel plays a large part in the matter.

"The only immediate suggestion I can offer is that experiments on the lines of those made by Parr and Straub should be carried out on steels of different origin, particularly on acid as well as basic steels and after various forms of heat treatment, including

a heat treatment which shall render the carbide granular or spherulitic instead of lamellar."

A consulting engineer of prominence who has had over forty years' experience in chemical and mechanical engineering, has furnished the committee the following opinion relating to the problem of embrittlement.

"The cases of embrittlement which have come under my observation have been so contradictory that I am led to believe that only certain qualities of steel are affected. By quality I mean physical quality. The chemical analysis seems to throw no light on this subject, and in the same apparatus one sheet of steel will develop minute cracks, which in many cases are in the middle of a sheet, while other sheets in the same apparatus and under the same conditions, last indefinitely.

"I have never known any case of embrittlement in boiler shells or steam drums of boilers, except with very concentrated liquors. I once tried the use of a water-tube boiler for concentrated caustic liquor from 20 to 30 deg. B. These boilers gave no trouble while in this service for a period of several months, but after being returned to ordinary boiler service, I found one of the seams of one of the drums had a crack along the calking of the longitudinal seam nearly three feet long, and the inside had a number of minute cracks extending from one rivet hole to the others, sometimes in two or three directions. This seam was cut out, taken apart and examined very carefully. The water was being treated with soda ash and lime and contained a small amount of caustic soda which was, however, not allowed to concentrate very much, but it was evident that if the water could leak into the space between the laps which were not very well drawn together, the caustic might concentrate in that particular seam and have an action on the steel which would not be possible with the low concentration.

"Following this were several others of a similar kind, where the drums had been used for concentrate caustic liquor and cracks were found by examination with a microscope in a number of other drums, always in the seams between rivet holes where the joints had been pulled together with drift pins, or where the severe calking had been done.

"I have also noticed that steel tanks containing hot 40 deg. B. liquor are gradually embrittled, especially in the seams. When struck with a hammer, after these tanks have been long in use, the rivet heads will pop off, showing in many cases cracks which are part way through the rivets, which had evidently been there a long time, but alongside of them were other tanks with 20 deg. B. liquor that had been in use for 35 years, some of them wrought iron, some steel, which were not affected.

"I have noticed in some cases where cast-iron pipe joints are held together with bolts and slight leaks of caustic liquor occurred, which ran over the bolts, that these bolts were broken in two in two places, or many of them half-broken in two. In one case of a large B. & W. "W"-type boiler, a lower drum developed some cracks in one sheet. Six other boilers running under the same conditions gave no trouble. A spare drum was ordered which has never been put in, and while the failure was laid by the manufacturers to embrittlement, and several learned reports were written on the subject, I have never been satisfied that the cracks were caused by the very slight amount of caustic soda present in the water."

Professor Baumann in a lecture before the Association of Steam Boiler Inspectors at Zurich, Switzerland, on September 7, 1926, stated that the evidence from laboratory tests indicated that the presence of caustic soda is not essential to the formation of intercrystalline cracks.

Dr. Guilleaume in a recent report stated that in all cases where steel failed in service, the failures were traced to thermal and mechanical causes. In no instance was it indicated that caustic soda had been responsible for the development of the fracture of the metals.

Last year, two important contributions on this subject appeared in Germany. Dr. Bauer, of the Metallographical Institute of Dahlen, has shown that hydrogen in contact with metal and under high pressure (up to 3000 lb.) will not affect the strength of the metal when the contact takes place at room temperatures. Dr. Bauer has demonstrated, however, that relatively small amounts of hydrogen in contact with iron or steel at boiler temperatures is readily absorbed by the metal, materially reducing its tensile strength.

Professor Thiel's research studies have shown that 77.5 per cent of caustic soda may concentrate in the clearances between the boiler plates, resulting in reducing the tensile strength of the boiler. This action, according to Professor Thiel, is due to the absorption of hydrogen which is released from the caustic soda when the sodium unites chemically with the iron.

An enlightening editorial on the subject of embrittlement appeared in Power in the August 17, 1926, edition of this periodical. A portion of this comment is quoted since it confirms the committee views that future research is highly desirable.

> "Are there not several kinds of causes for embrittlement? Are all embrittlement cracks from the same cause? The boiler user is intensely interested in the answers to such questions.
>
> "But the boiler user cannot be content to sit idly awaiting the conclusions of what is to him in a measure an academic question. After all he cares little by what name his trouble is called. His demand is for some remedy that will enable him to operate safely. Whether the remedy is scientifically rational or purely empirical is interesting, but not vital to him. Even a 'hunch' is good enough for him if it works. True, there may be a cheaper and better way to be developed through further research, and this the operator wants, but he dare not wait for it. He must do something now.
>
> "What shall he do? Two factors are involved—stress and water conditions. Perhaps the elimination of either alone will cure the disease, but since both are under suspicion, why not do all that can be done to eliminate both? Severe internal stress is admittedly bad on all counts. Let every effort be made to eliminate it by insisting on first-rate material and the best possible shop practice. Certain materials in solution in the feedwater seem also, in some instances at least, to be a contributing cause. Let care be taken in adding such things to the water or in neutralizing them if they are already present."

Your committee has attempted to summarize the work of the various investigators and to present the viewpoint of those who have advanced the

theory of embrittlement due to high concentrations of caustic soda and that of those rejecting this premise. The latter call attention to the following phenomena which may influence the failures.

Gaseous hydrogen from any source may penetrate steel and be occluded by it, resulting in embrittlement of the metal. This phenomenon may take place not only from caustic soda but from any other source. Excessive strains set up in the metal may be the primary cause for embrittlement and the source of intercrystalline cracking. Intercrystalline cracks may be developed in ferrous and non-ferrous metal due to improper thermal treatment in the manufacture of the metal.

The advocates of caustic embrittlement tend to direct attention to the quality of water as the offending agent rather than the material in the boiler or the method of fabricating the equipment. Failures of this kind have occurred largely in certain sections of the country where the water used for boiler feed contains relatively large quantities of sodium carbonate and bicarbonates and is low in sulphates or chlorides. In many instances, the difficulty has disappeared entirely by changing the source of the feed-water and using water that did not have these characteristics or by treating the water chemically so as to maintain a predetermined ratio between the carbonates and sulphates.

The difficulty has not been confined to boilers of any one manufacturer, thereby tending to eliminate the theory of faulty design and construction or dirty metal. Embrittlement of metal has been produced by investigators by duplicating conditions that theoretically should be favorable to producing the characteristic intercrystalline cracking of the metal.

A complete bibliography of the subject of embrittlement of metals has been prepared by the Engineering Library, 29 W. 39th Street, New York, copies of which can be secured for a nominal charge by any one interested in this subject.

RECOMMENDATIONS

Most of the experimental work which has been carried on has been with waters high in carbonate or bicarbonate of soda. Little information is available concerning the possibility of embrittlement of boiler metal in waters low in these salts. It has already been demonstrated in one case reported to the committee that embrittlement of boilers may and has resulted from the use of feed water low in sodium salts.

Little information is available concerning the effect of dissolved gases in accelerating the phenomenon of embrittlement.

High pressure as a contributing agent has not been established. There are many other factors entering into the problem which up to the present time have received no special attention from investigators of these problems. It is evident that there is much still to be learned concerning the cause or causes of intercrystalline cracking of boiler plate and much is to be learned concerning the methods of controlling the contributing factors.

The preceding paragraphs present a brief digest of the great mass of data submitted to the committee. A careful study of all of this material has led to the formulation of the following recommendations:

(1) In view of the wide diversity of opinion on the cause of embrittlement, extensive research should be started to determine the influence of all possible contributing factors.

(2) Plans for such research should be formulated to give cognizance to causes of embrittlement other than those which may result from the use of waters in which high concentration of caustic soda is potentially possible.

(3) Not only must the causes of embrittlement be determined but means of preventing its occurrence under all conditions should be developed as soon as all contributing causes are known.

(4) Since the plate ligament or the rivets in riveted joints may be stressed beyond the elastic limit of the metal, a study of other means of joining plates such as welding, is a logical step in the elimination of embrittlement troubles.

(5) This research may be carried out in University laboratories but funds must be obtained to finance this experimental work.

(6) This committee should be continued to co-ordinate the research work and to report developments in the study of Embrittlement of Metals.

SINK-HEAD INGOTS

R. S. Harden, Office Engineer, The Pennsylvania Railroad

There is an old adage predicting the impossibility of making a silk purse out of a sow's ear; the underlying thought being that inherent unrefinement in individuals cannot be glossed over or coated with a veneer of culture so perfectly that intrinsic baser characteristics will not be displayed inevitably at some time or other under stress.

And it is equally as impossible to produce refined rails from uncouth ingots; for any unsound metal that may exist in the ingot cannot be made perfect by rolling, so that the imperfections are obliterated and do not remain as points of weakness to develop into failures of various kinds when the rails are subjected to the stresses produced by loads moving over them at high speed. What is bred in the ingot is bound to come out in the rail.

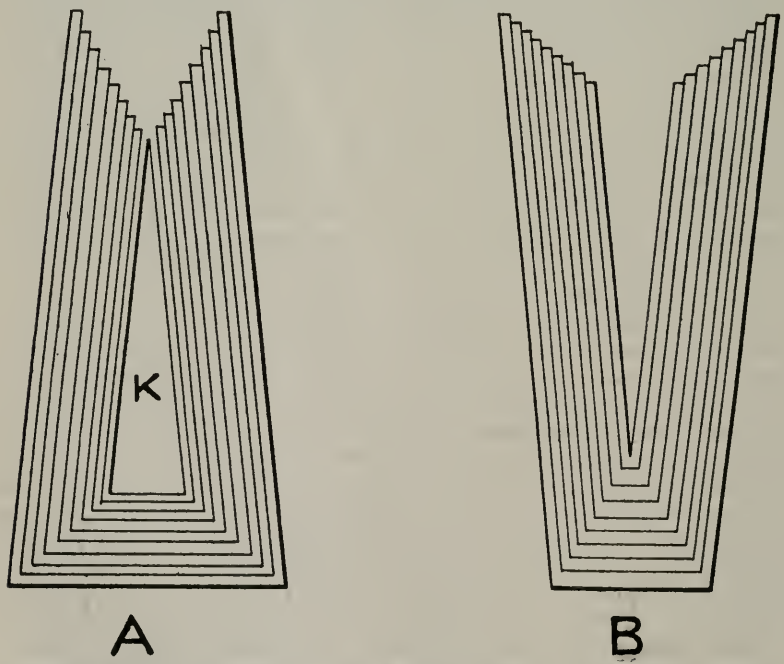
The prime requisite, therefore, in rail making should be to secure an ingot of steel that is homogeneous and of perfect continuity throughout.

The present American practice of casting in a tapered mold with the small end uppermost, of striking a happy medium in the deoxidizing process between blow holes and piping, and scrapping a large portion of the ingot to avoid these defects and segregated material, does not always provide this. It does not inspire perfect assurance that the lower portion of the ingot, remaining after the evidently poor material at the top has been discarded, is composed completely of sound material; that there has been a progressive freezing of the molten steel from the bottom upward without bridging and the consequent pools of liquid below that later solidify, shrink and produce imperfect conditions.

The desideratum is, of course, an ingot perfectly free from blow holes, shrinkage cavities, segregation and foreign matter. Unfortunately these defects will occur to a greater or less extent in all ingots cast in the usual manner. And there are reasons why they may be expected to occur. Steel in a molten state occupies more space than after solidification and, since the outsides of the mass freeze first, fixing the size, the volumetric shrinkage shows itself in one or the other of two ways. Either as a central cavity or pipe and a more or less complete absence of blow holes, in the case of steel that has been thoroughly deoxidized and so quieted or killed to avoid the evolution of gases, or, in steel not deoxidized, as innumerable blow holes, the result of trapped gases that failed to reach the surface and escape. Killed steel pipes and lively steel produces blow holes, and in either case it is necessary to crop and discard all metal evidencing these defects. In addition, selective freezing brings about a lack of uniformity in the distribution of the elements affecting strength, more pronounced in lively steel than in that which has been quieted. Unluckily, the defects occurring in the upper portion of the ingot and brought to light by cropping and examination are not

always the only ones existing. Farther down in the ingot, and usually undetectable, may be unsatisfactory conditions that are solely the result of the practice of casting in a mold that is smaller at the top than at the bottom. Concerning this practice there appeared in "The Engineer" of London, October 6, 1916, an abstract of an article entitled "Some Properties of Ingots," by A. W. & H. Brearley, *that had been presented at a meeting of The Iron and Steel Institute of Great Britain, which elucidates the progress of the solidification of steel in molds having the larger or smaller end up.

"**The Taper of Ingot Molds.**—If it is assumed that a taper ingot mold with the narrow end upward is full of fluid metal at a uniform temperature the act of setting may be represented by a series of equidistant lines drawn on a longitudinal section of the mold parallel to its inner surface, as in A, each line being made shorter than its predecessor to account for the continuous shrinkage. The point at which a pair of these lines meet within the mold may be taken as indicating that in the horizontal plane passing through it the metal has solidified completely. The cavity above the point of intersection is a pipe pure and simple, and may be distinguished as "primary pipe." But there still remains a triangle marked K, which, according to our assumption, con-



tains fluid metal and is hermetically sealed. This fluid in due course will also shrink and freeze and contract, but there is no possibility of the cavities thus formed being fed, and there is formed thus a more or less

*Proceedings American Railway Engineering Association, Vol. 18—1917—page 1075.

discontinuous extension of the pipe, which may be called 'secondary pipe.' On representing in the same manner the freezing of metal cast into a taper mold with the wide end up, but with shorter steps down because the shrinkage fluid is falling from a wider into a narrower part, we arrive at B. Here also the lines intersect and represent similarly that the material lying below the point of intersection has become solid. There is also a triangular residue of fluid metal, but in this latter case the triangle is inverted, and the metal within it will freeze earliest at the lowest point, any shrinkage being meanwhile fed from above, and leave finally a hollow shrinkage cavity in the axis and at the upper end of the ingot. It is not possible in this kind of ingot to have a secondary pipe. Nothing can be done to prevent the shrinking of fluid steel as it passes from the liquid to the solid state; and the only means of providing against the inconvenience of it is to arrange for fluid metal to be kept at a higher level ready and able to flow into what otherwise would be a shrinkage cavity. This means that an ingot must always solidify from the bottom upwards, which it does naturally when cast into a taper mold with the wide end up. . . . "

Mr. E. F. Kenney* also says that:

"Care in making and pouring the steel and thorough deoxidation can be depended upon to minimize segregation to such a degree as to remove all apprehension as to any serious detriment due to it, but in carrying out these remedies, in connection with the ordinary practice, we have introduced an element which is just as objectionable. This is the internal shrinkage cavity or 'pipe.' This much misused word applies to the cavity left in the interior of a casting or ingot by reason of the cold metal occupying less space than the same amount of metal while hot, and the shape and size of the cavity will be dependent on the shape of the ingot, the temperature and speed of casting and the relative speed of cooling of the various parts. While various types of special ingots are used for special work, there seems to be one general type which is in almost universal use in the large steel plants. . . . These ingots have a taper of about one-quarter to one-half inch per foot of length, the top being materially smaller in section than the base. The ingot mold walls are made heavy to quickly absorb the heat from the ingot and cause it to freeze rapidly, and solidification proceeds with fair uniformity over the part of the exterior of the ingot which is in contact with the heavy metal walls. If the cooling were absolutely uniform, the last metal to freeze would be toward the bottom where the ingot has the maximum section, but the lesser density of the hotter metal causes it to rise and thus interferes with the absolutely uniform freezing of the exterior walls of the ingot, so that ordinarily the last portion to freeze is toward the upper end. This cooling of the upper portion last, however, is in spite of the taper of the ingot, and too frequently the effect of the taper and the tendency of the hottest metal to seek the top of the freezing ingot interfere with one another to such an extent that the freezing metal bridges from one side to the other, and prevents the lighter portions of the molten metal from rising to the top. A pool of molten metal below such a bridge acts as a center of shrinkage and segregation. As it cools and solidifies, it shrinks and, its volume being less, a shrinkage cavity results. The bridge very effectually prevents the void being filled by liquid metal from above, and we have a pipe

*Then Metallurgical Engineer, Cambria Steel Company, "The Commercial Production of Sound and Homogeneous Steel," read at the meeting of the American Iron and Steel Institute, May 28, 1915.

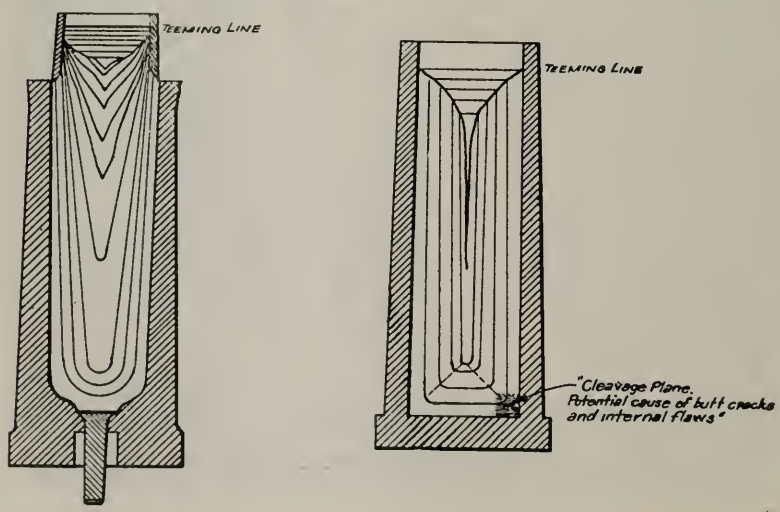
existing at a point where no well-behaved pipe should be, so far down the ingot that ordinary discard would not remove it. . . . Unfortunately, this is not an infrequent occurrence; the tendency is always present in an ingot which tapers toward the top, and even where actual piping does not develop there is frequently present a loose spongy structure which, in the opinion of the writer, is responsible for many of the unexplained failures of steel in service.

"Even where bridging has not developed sufficiently to break the interior of the ingot into separate pools, the tendency of the upward tapering ingot to pipe deeply is so marked that any effort on the part of the steel maker to thoroughly deoxidize his heats results in such deep piping, and therefore necessity for so much top crop, that the practice is regarded as not being commercial. . . .

"The inverted ingot is highly efficient in preventing the occurrence of irregularly located pipes and segregated areas. In that type of ingot, the solidification is always progressive from the bottom upwards; the last metal to freeze is always at the upper portion of the ingot, and bridging is practically eliminated. Consequently, when we crop off all the piped portion from the top, we can feel assured that we have left only solid steel. Such assurance we never have or can have with the upward tapering ingot. The difficulty with the large topped ingot is that its greater top section means a greater amount of metal discarded for each inch of depth to which the pipe extends, and yet such greater section is what has insured us the progressive upward solidification which is so essential."

Emil Gathmann and George A. Dornin, in a pamphlet entitled "Unsoundness in Steel—and Fundamentals Essential to Soundness," being literature of the Gathmann Engineering Company of Baltimore, Md., advocating the use of Gathmann ingot molds and refractory sinkheads or feeders, present the matter in the following way:

Diagrammatic Sketch Showing the Freezing or Formation of Ingots of Well-deoxidized Steel.



"The big-end-up and big-end-down molds of the same size and cross-section are illustrated, and by means of contour lines freezing or successive ingot skin thicknesses illustrate the method of solidification and the type of shrinkage cavity produced in the ingots made in these two types of molds.

"It is essential, in order to prevent a deep-seated pipe in the solidified ingot, that the growth of the pine-tree crystals should be induced or accelerated from the bottom of the ingot upwardly. This method permits a continuous body of liquid steel to automatically extend to the upper portion of the ingot, and thus reduce the depth of the shrinkage cavity or pipe, due to the decrease in the volume of steel within the original skin or envelope initially solidified by contact with the walls of the mold cavity. The best and most economic results in the formation of this type of casting are obtained by employing the big-end-up mold, and in so shaping the ingot that it will have a continuously increased volume of horizontal cross-section from the bottom of the ingot upward. The final reservoir of molten steel for feeding the portions of the ingot located below the refractory top portion of the metallic mold is provided by means of a suitable refractory heat insulating sinkhead as shown."

It is believed that opinions in general will agree with the statement that inverted ingot casting produces superior steel and that this method ought to be adopted as the universal rail practice of American mills. Added to the objection of requiring a larger volume of discard, cited by Mr. Kenney, which can be obviated, is a disinclination on the part of steel makers to upset the routine that makes possible the large tonnage production for which the sequential operations of their plants are laid out. To cast large end up would, of course, require changes in the molds, stripping and, perhaps, soaking pit arrangements, and, at first, would slow up production to some extent and involve expense, but it would not be long before the new practice had become the routine, production built up again and any extra expense dissipated. And with the change would come the assurance, that is not now entertained, that the lower portion of the ingot contains sound steel.

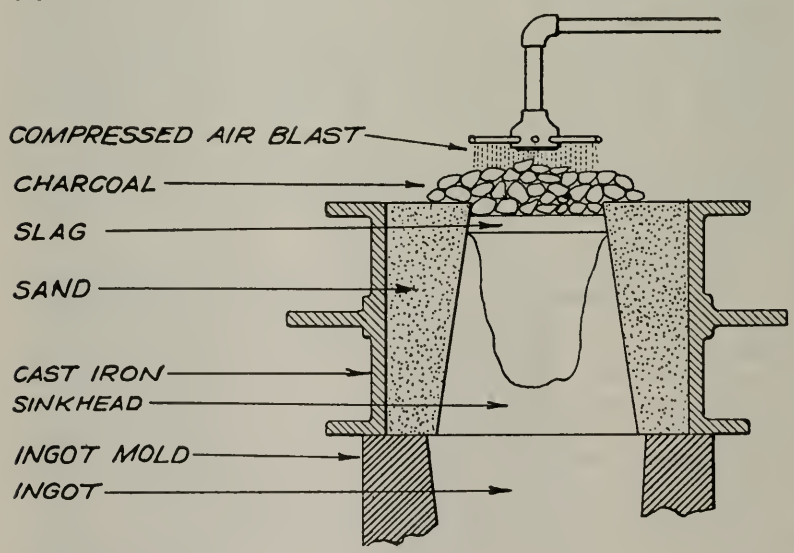
The principle has long been recognized that the surest way of obtaining solid and sound ingots is to produce a piping steel by thorough deoxidation and then by means of a supplemental mold, lined with fire-brick, sand, loam or other suitable insulating material, placed on top of the inverted ingot mold, provide a reservoir of molten metal that will feed the ingot and automatically prevent the formation of a shrinkage cavity within the ingot itself. The sinking of the metal that finally takes place upon complete solidification is contained wholly or principally, depending upon the relative sizes of the ingot, the top and cavity and the conservation of heat in the head, within the so-called sinkhead.

The idea of using a sinkhead on rail ingots first gained stimulus as the result of experiments and two papers by Sir Robert A. Hadfield, F.R.S.* These papers, "Method of Producing Sound Ingots" and "On a New Method of Revealing Segregation in Steel Ingots," were presented at a meeting of the Iron and Steel Institute of Great Britain in 1912,

*Past-president of the Iron and Steel Institute of Great Britain and manufacturer of steel at the Hecla Works in Sheffield, England.

and permission was given by their author to Mr. W. C. Cushing** for their publication in the Bulletin of the American Railway Engineering Association. (Vol. 14, No. 151, November, 1912.) Since that time the subject has been very thoroughly covered in brochure and discussion, so that it is not the intent herein to add new thoughts on the matter, but rather to form a compendium of some of that which has been written, as well as to present such data as has been obtained regarding rail rolled in 1914 from sinkhead ingots for the Pennsylvania Railroad Company.

The Hadfield system of making sound ingots, covered by letters patent Nos. 933,751, 954,183 and others, "consists in heating the metal in the upper part of an ingot or other mold and maintaining it in a liquid condition by the combustion in contact therewith, or in close proximity thereto, during the cooling and shrinkage of the metal in the lower part of the mold, of solid fuel—for example, charcoal—by means of a blast of compressed air which is caused to impinge on the fuel while the fuel is directly or indirectly supported by the metal below; also the interposition of a layer of fusible material, such as iron slag, which has no injurious action on the metal, between the metal and the fuel."



Sir Robert Hadfield has been very successful in making thousands of ingots of various sizes by his sinkhead method from which it has been necessary to discard only a small amount of undesirable material to

**Then Chief Engineer, Maintenance of Way, Southwest System, Pennsylvania Lines West of Pittsburgh. Proceedings American Railway Engineering Association, Vol. 14—1913—page 449.

reach sound steel. The percentage of discard of course varies, ranging from seven to perhaps 12 or 15 as in the case of the exacting requirements of the British Government for shells.

As a case in point, he has made ingots weighing 4340 lb. each, including the head. The sand heads were 14 inches square where they joined the ingot, tapering to nine inches square in a height of 16 inches. The steel was poured to a depth of 14 inches in the heads, with a 1½ inch layer of slag on top. Heating was carried out by means of charcoal and air blasts. Upon solidification 290 lb. of the original 573 lb. of steel in the head remained in the head, or 49 per cent of the steel in the head had passed into the ingot. This represented 6.5 per cent of the original volume of molten steel in ingot and head.

The analysis of the heat was C. 0.50, Si. 0.16, S. 0.033, P. 0.037, Mn. 0.80 and this composition was found to exist in the ingot about where the head joined it. About 7 per cent discard.

While these ingots weighed only about two tons, it is possible to cast successfully much larger masses. M. Charpy, in France, following the Hadfield method, made an ingot of steel weighing 25 tons from which only about 5 per cent top discard was necessary.

The Pennsylvania Railroad Company purchased from Sir Robert A. Hadfield in 1915 thirty-seven ingots (about 100 tons) made by his sink-head method with the large end uppermost at his Sheffield Works in England. These ingots were shipped to the Sparrows Point plant of the then Maryland Steel Company where 35 of them were rolled into rails, the other two being sectioned longitudinally for examination. For comparison, five ingots were selected from each of three Maryland Steel Company heats; each group of five representing a distinct practice in open-hearth manufacture. These ingots were cast small end up without sinkheads.

Group I

Rising steel, chilled on top with cast iron caps. Segregation high and variable. Top discard to avoid material having carbon segregated more than 12 per cent ranged from 23.7 to 31.9 per cent. The amount of segregation in a single ingot ranged from 26.5 to 94.6 per cent. Top discard to eliminate piped material varied from 2.6 to 9.3 per cent. High negative segregation found in lower portion of the ingots, ranging from —12.3 to —15.9 per cent. Total material that should be cropped from ingots of this method to avoid segregation would vary from 58 to 64 per cent of the ingot.

Group II

Rising steel treated during teeming with two ounces of aluminum per ton of steel and ingots chilled on top with water. Had a greater tendency to pipe than ingots of group I. Top discard, for carbon segregation above 12 per cent, ranged from 23.3 to 25.3 per cent. Top discard to avoid pipe was 8.0 per cent. This group required the least total discard of the three heats.

Group III

Quieted or killed steel. Treated with two ounces of aluminum while being cast, but not chilled on top. Steel had pronounced piping tendencies and approached the Hadfield type of steel. In this group the amount of top discard was governed by the depth of piping, while in the other two groups the segregation of carbon was the determining factor. The average discard; piping 26.8 per cent, segregation 16.4 per cent. The total discard was intermediate between groups I and II.

Characteristics of Maryland and Hadfield Products

		Maryland ordinary practice 15 ingots	Hadfield sinkhead method 35 ingots
1	Size of ingot mold, top	18¼" sq.	19½" sq.
2	Size of ingot mold, bottom	19¼" sq.	17¼" sq.
3	Size of ingot mold, height	63"	50½"
4	Average top discard, per cent	26	13.0
5	Average total discard, per cent	43.9	18.4
6	No. 1 rails produced	53 or 93%	46 or 43%
7	No. 2 rails produced	4 or 7%	61 or 57%
8	Carbon content, per cent	0.645	0.648
9	Average deviation from the mean	0.036	0.017
10	Manganese content, per cent	0.70	0.89
11	Phosphorus content, per cent	0.019	0.032
12	Sulphur content, per cent	0.095	0.047
13	Silicon content, per cent	0.151	0.138
14	Chromium content, per cent	0.28*	....
15	Nickel content, per cent	0.75*	....
16	Ultimate strength, lbs. per sq. in	124,545	125,771
17	Elongation, per cent	13.6	13.8
18	Elastic limit, lbs. per sq. in	61,370	62,700
19	Reduction of area, per cent	25.78	24.38
20	Hardness, Brinell	250	260
21	Abrasion No. 1 rails (after 11 months)	0.37 sq. in.	0.42 sq. in.
22	Abrasion No. 2 rails (after 4 years), per cent of head area	9.7	16.1

*Cuban ore.

As will be noted there were an unusually large number of seconds (57 per cent) from the Hadfield ingots because of surface imperfections, which compares with 7 per cent from those of the Maryland Steel Company. Concerning this difference Dr. George K. Burgess* remarks:

"There appears to be no reason why ingots of the sinkhead type should not be as well-surfaced as any other, and the high percentage of seconds should not be attributed to the type of ingot, as the bottom of the sinkhead was well within the A rail, which was not classified. Probably the severe and unusual re-heating conditions contributed somewhat, together with the original surface condition as influenced by condition of the molds and teeming practice, toward producing the large number of seconds from the Hadfield ingots."

*Then Physicist, Bureau of Standards, Department of Commerce; "Steel Rail from Sinkhead and Ordinary Rail Ingots."

Sulphur prints of the cross-section of the two makes of rails indicate a finer grained material composed the Hadfield than the Maryland rails and, in general, there was a smoothness and evenness of tone of the prints of Hadfield rails that was lacking in those of the Maryland product.

From the Hadfield ingots there were obtained 46 No. 1 and 61 No. 2 P. S. 100-lb. rails and from the Maryland ingots 53 No. 1 and 4 No. 2 rails. The Maryland and Hadfield No. 1 rails were laid November, 1915, in the eastbound passenger and freight tracks (5°30′ curve) between Spruce Creek and Union Furnace on the Middle Division and removed in October, 1916. Average abrasion, Hadfield 0.42 and Maryland 0.37 square inches.

The No. 2 rails were laid west of M. P. 69, eastbound track of the Low Grade Line, Philadelphia Division, on a two-degree curve, and removed in February, 1920. Average abrasion in per cent of head area, Hadfield 16.1, Maryland, 9.7. The nickel and chromium in the Maryland steel may have had a decided influence in reducing abrasion.

There were no failures in any of the Hadfield or Maryland rails.

The complete report of this Hadfield and Maryland steel by Dr. Burgess is attached (Appendix C). In addition, results of tests of four No. 2 Hadfield and two No. 2 Maryland rails removed from the Low Grade Line in 1920 on account of wear are given in Appendix B.

On the subject of the shrinkage of ingots Sir Robert Hadfield writes in his paper "Sound Steel for Rails and Structural Purposes" as follows:

"To show how considerable is the cavity which forms in piping steel, nine 15-inch ingots were taken (weighing about 3600 lb. each) as they came through, each of which had the sand head and the writer's (Hadfield) improved method of feeding carried out on them. After the ingots had cooled down, the hollows or cavities in the sand heads were filled with water, then the water poured out and carefully measured. . . . The average weight for the nine 15-inch ingots showed that 139 lb. with a minimum of 123 lb. and a maximum of 162 lb., passed from the head portion into the ingot itself. . . . It is not claimed that ingots made in the ordinary manner are deficient to the full extent of, say, 4 per cent, even when the steel is sound, which, unfortunately, is usually not the case. There is a certain amount of feeding effect from the steel in the upper portion of the ingot, but this is not done efficiently, as the steel quickly freezes on the outside of the mold and on the surface of the liquid steel exposed to the air. Moreover, there is always an uncertainty as to how good or how bad is the resulting material. If the steel is piping very much, the trouble will be worse than when it is piping less. In any case, the steel solidified in an ingot of this size, the natural law of contraction demands that about 500 cubic inches have to be dealt with; that is, on an ingot of the weight and size mentioned. The writer (Sir Robert Hadfield) cannot see how this can be efficiently and cheaply met except by some such method as described in this paper. . . . While in ingots made in the ordinary way a certain amount of the fluid steel passes from the upper portion to the lower, still in so doing it is robbing the quality of the upper portion of the ingot itself, which has no fluid metal above it to feed or take the place and supply the deficiency thus created. It will be readily understood, therefore, why the upper portion of ingots is so

seriously affected as regards their soundness, also why segregation occurs. . . . Moreover—and this is a most important point—the steel in the fed ingots, being maintained fluid in the head portion, continues to exert its ferrostatic pressure, whereas with ingots made in the ordinary way the ferrostatic pressure on the center portion of the ingot is so slight that it produces very little beneficial effect. Further, without the feeding head above the ingot proper, the outside of the ingot in the ordinary ingot mould becomes rapidly chilled and frozen, so that it cannot contribute its proper share to the feeding of the remaining portion of the ingot. . . .

"There would probably be more dangerous ingots but for the fact that the steel maker tries to avoid this type of steel, and aims to make steel which when poured into the ingot will not pipe. Nevertheless, he is still fighting against a natural law. If piping steel is checked or avoided, he runs the risk of producing unsound steel, especially in the upper portion of the ingot, more or less permeated with blow holes. Thus, owing to lack of feeding from the upper portion, the center, or that portion on the axis line of the ingot, must be of inferior nature, as the piping characteristics persist for quite a long way down the ingot. This, as before mentioned, is for the reason that, owing to the want of ferrostatic pressure, the ingot lacks feeding from above, which, in the system of casting ingots now described, is maintained to a very late stage; that is, until, or close upon, actual solidification takes place. There is always fluid steel in the upper portion of the ingot to feed the piping and shrinkage, both of which must occur as they follow a natural law. This, too, is the reason why there is so little segregation in ingots made under the writer's (Sir Robert Hadfield) system, and also explains why the ferrostatic pressure is kept up to a very late stage. In fact, check or hinder ferrostatic pressure, and segregation with its bad effects at once commences. In the case of 'fed' ingots, the smaller amount of segregation which occurs takes place outside the ingot proper; that is, in the head."

Four features are essential to the successful casting of sound ingots by the sink-head method: The steel must be of a piping nature; the mold must be of larger cross-section at the top than at the bottom; time must be allowed to permit proper feeding of liquid steel into the ingot, and the character of the top must be such that the steel will remain liquid therein until or after that of the ingot has solidified.

In the Hadfield experiments to determine the condition of the interior mass of the ingot, a thin iron rod was inserted in the casting at short intervals after teeming, with the following results on an 18 inch ingot. In 25 minutes the metal was solidified at the bottom a depth of 6 inches; in 40 minutes, 13 inches; in 55 minutes, 55 inches; in 60 minutes, 58 inches; and complete solidification shortly thereafter. This will vary, of course, with different sized ingots, temperature, etc., up to, perhaps, two hours or more, and it would be desirable to find a means of complying with the third essential, of allowing time for proper feeding, without the loss of time and heat resulting from holding the ingot in the mold until complete solidification. Mr. Kenney has devised a sinkhead of cast iron with a lining of loam which permits the removal of the cast iron form when the ingot has been poured, allowing the loam top to remain on the ingot when charged into the soaking pit, where solidification takes place. It does, however, bring about the destruction of the loam top, which is

not the case in the Hadfield method. His sand heads are used from 3 to 6 times, the only attention being some slight patching up. It is questionable whether a layer of fusible material, charcoal and an air blast are entirely necessary, and practicable from the standpoint of American production. It is possible that the same results can be attained by increasing the height of the sinkhead and by using a good insulating material.

Quoting from Mr. Kenney's paper:

"It is quite evident that the efficiency of the non-conducting top will determine whether or not external heat is necessary. If a top can be obtained that will keep metal molten within it, until all the ingot below the sinkhead has congealed, there is evidently no necessity of applying heat. The material which has been most commonly used in the making of non-conducting ingot mold tops is fire-brick. Because of the comparative fragility and the conductivity of this material, these sink-head bricks have been made heavy. Bricks made with an admixture of sawdust or similar material which would be destroyed in the burning, leaving voids scattered through the mass to reduce conductivity, would probably be more efficient, but the reduced strength of the resulting brick would probably necessitate making the bricks even heavier than those ordinarily used. Tops of thin metal have been tried, but the heat loss is so great that no appreciable effect is produced. The writer (Mr. Kenney) has used a top composed of a metal casing enclosing a thin lining of dried loam. The loam is rammed into position while moist, is easily and quickly dried, the elimination of the moisture leaving the loam in a very porous condition. The conductivity of this dried loam is so slight that the bare hand can be held on the exterior of a 2½-inch casing on an ingot, while a 5-inch fire-clay brick is so hot that it will burn the hand. . . .

"With the very efficient heat insulation obtained with dry loam, it has been found unnecessary to apply heat to keep the metal in the sinkhead molten. . . ."

The principal essentials in the practical application of the sinkhead to the ordinary methods of steel making in commercial use are (quoting Mr. Kenney):

(1) That the ingot be carried through the heating and rolling operations without the necessity of becoming cold.

(2) That sinkheads be of such a type that ingots of varying weights can be cast from the same ingot molds.

To get the solidity desired it is not necessary that the ingots become cold. There is little to be gained by carrying the temperature of the ingot through the range between the solidification point and atmospheric temperatures, and there are very decided objections to it, chiefly the loss of heat, and cost of replenishing it, and the risk of damage to the ingot in reheating. Any betterment in quality obtained in allowing steel to become cold and then reheating through the critical range is much more economically and safely accomplished after the steel is in the form of a bloom.

The function of the sinkhead being the preservation of a reservoir of molten metal on top of the ingot until all the body of the ingot has solidified, it follows that the non-conducting jacket should be kept on the top of the ingot when it is charged hot into the pits. The temperature of the soaking pits is lower than the freezing point of the steel, and there would consequently be a loss of heat from the sinkhead even

in the pits if there were no protecting jacket. The loss would be much less rapid than in an atmosphere at lower temperature, but the very fact that the ingots solidify throughout while in the pits shows that there is a considerable loss of heat from the molten metal. The proper thermal treatment of high carbon heats involves the use of comparatively cool soaking pits when ingots are charged. It would be quite possible for the small mass of molten metal comprising the sinkhead, if unprotected, to lose heat to such an extent that it would solidify before the greater volume of the ingot. The value of the sinkhead in this event is gone, as on further contraction of the liquid metal in the ingot there could be no feeding from the sink-head which has solidified. . . .

This loam used by the writer (Mr. Kenney) does not have to be removed from the ingot before the latter is charged into the pit furnaces, but can be allowed to remain on until the ingot is bloomed, being so plastic that it does not affect the rolling. The practice used in connection with these sink-heads is as follows: A wooden form of the dimensions of the sinkhead extension desired is placed inside the metal sinkhead casing, leaving a space 2½ inches wide between the form and the casting. This space is filled with moist loam well rammed. The loam and casing are then dried, the drying requiring about two or three hours in a pit oven. A number of wooden pegs around the bottom of the casing prevent the loam lining from slipping from the casing while the whole is being handled and set on the ingot molds, and the steel is poured in the usual manner. When the metal reaches the sinkhead, the wooden pegs are burned off, releasing the iron casing, so that it can be removed, leaving the loam lining attached to and protecting the sinkhead against heat loss. The iron castings do not leave the open-hearth, being promptly removed and rerammed with fresh loam. The loam lining remains on the ingot until it is rolled, which insures against trouble which would result from delays in charging after the protective covering was removed, or the necessity of banking steel, or any of the many possibilities of commercial steel works' practice, which interfere with the regular routine. In practice, this type of sink-head, besides being more efficient thermally, has been found much cheaper than the regulation brick, and, as stated above, has possibilities which make it much more applicable to ordinary steel works' practice.

In addition to the quality, betterments which are possible by the use of inverted ingots with sink-heads, there is possible a very great economy because of the much smaller percentage of metal which has to be cropped from the top, as compared with the cropping which is necessary with the ordinary ingot. . . ."

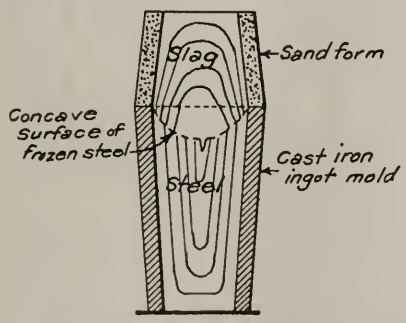
The value of the sink-head in getting a large percentage of solid steel from the ingot will be materially reduced unless we can regulate the size of the ingot to produce the amount of metal needed. In ordinary practice today this is easily accomplished by pouring the steel to any desired height in the molds. For instance, in most works producing rails, a single size of ingot mold is used, and ingots to economically produce any weight of rails are cast in the same mold. For 90 lb. rails only about nine-tenths of the amount of metal is poured into a mold which would be poured if the same number of 100 lb. rails were required. Similarly in other products, the weight of the ingot is varied to give the amount of steel required for a given prod-

uct. Practically all sink-heads used in the past have been so designed that they were set at the top of the ingot mold, and no variation in the weight of the ingot was possible with a given mold. This feature would necessitate an extraordinarily large equipment of molds of various sizes, or else result in the scrapping of considerable quantities of steel. Both of the difficulties will be avoided by the use of a sinkhead which can be set at any desirable height in the ingot mold in accordance with the amount of metal required in the ingot for the particular purpose in view.

This adjustable feature has been tried out in connection with the dried loam sink-heads, and is quite practicable. Several thousand tons of rail ingots have been cast with sink-heads which embodied this feature, the ingots being cast 7 inches shorter than the molds, thereby making a very considerable saving in the scrap loss.

It is practicable to provide for the conservation of the greater part of the original heat and the adjustability of the size of the ingots in connection with inverted ingots equipped with sink-heads, and there seems to be no reason why practically all of the piping steels could not be cast in ingots of this type without incurring excessive costs."

Mr. Gustav Lindenthal* has proposed that molten neutral slag, prepared in a special furnace, be carefully poured upon the steel in the ingot form to a depth of about 20 inches from a special ladle following immediately the ladle with the steel. "The slag having a lower melting point than steel should be preferably superheated. Its melting point can be lowered and its fluidity increased, if desired, by the addition of litharge."



"The cast iron ingot mold can either be made longer by the twenty inches or, if more convenient for operation, a sand form twenty-two inches deep can be set upon the ordinary ingot form to contain the top layer of molten slag. The principle of this method is old and well known. But the trouble heretofore with it when used at all was that the slag was poured only a few inches deep, which is not sufficient for the retention of heat and keeping the top of the steel fluid to the last. . . . The large amount of latent heat in a deep body of slag is ample for the purpose, and there is besides the advantage that the fluid static pressure of the slag will cause the molten steel below it to flow more readily

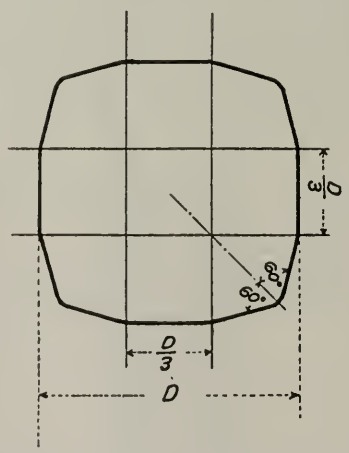
*Consulting Engineer, New York City, "Conditions Affecting Soundness of Steel Rails," 1915.

down into the lower part of the ingot, which cools and shrinks first, so that no pipe in the steel can form at all, which is the important point. No pipe and no segregation in the interior of the ingot. The top of the frozen steel ingot will form a deep dish containing the segregated matter on its concave surface below the slag and a pipe or cavity may form in the slag, where, of course, it is of no consequence.

"The additional work and expense for this item will consist in melting and pouring the slag and in separating or shearing the slag from the ingot after stripping. . . . The sheared-off slag can be melted and used again. The ingot is then inserted into the reheating furnace or soaking pit with non-oxidizing flame and reheated to a uniform waxy condition in the usual way, but with the big end down so that any adhering slag and impurities, having always a lower melting point than steel, may run off. . . . The discard will be certain and small, probably not over 5 per cent of the weight of the ingot against 15 to 25 per cent in the present rail steel practice with uncertain results. . . ."

In 1915 it was contemplated to cast five experimental ingots on this basis, but, upon detailed explanation of Mr. Kenney's method used at Cambria Steel Works, Mr. Lindenthal concluded that there was no need for the trial of his idea.

The Gathmann Engineering Company (refer to page 4) proposes the use of their patented molds and sink-heads, the molds being of polygonal cross-section yet substantially square as shown below.



The purpose of this section is to avoid as much as possible parallelism in the axes of dendritic crystallization. As set forth in their pamphlet:

"The ingot solidifies in the mold by crystallization, which starts at right angles to the ingot's exterior surface, both sides and bottom. If this surface is in contact with the mold chamber walls of a plain rectangular contour, either at the base or the sides, it follows that the axes of dendritic crystallization are mostly parallel lines resulting in the formation (where these axes intersect due to corners) of cleavage planes injurious to the strength of the ingot. These cleavage planes are more pronounced in well-deoxidized ingots than in ingots produced from a grassy or boiling molten metal. It has long been well known that if the vertical surface of the ingot is suitably corrugated or fluted, or of a polygon cross-section, the axes of crystallization are crossed and inter-

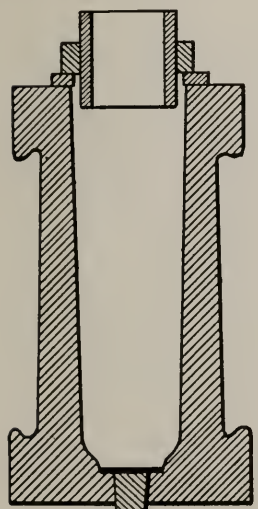
woven and hence eliminate, or at least greatly reduce, these planes of cleavage and thus give a stronger ingot structure. . . .

"From the supervision at many steel plants of the production and working of thousands of ingots of various commercial sizes, we are satisfied that the method of solidification of an ingot controls not only the physical characteristic of the surface of the ingot, grain structure, freedom from ingotism and excessive segregation of the constituents of the steel, but also has a pronounced effect on the purity of the steel and the amount of non-metallic inclusions that will be found in the finished product.

"The sound steel ingot should not be stripped from the mold, or the mold from the ingot, until the ingot has become substantially solidified throughout its entire volume. In high carbon and alloy steels this time interval is considerably greater than in low carbon or open steel.

"In stripping, the ingot may be either caught by its sinkhead with suitable tongs and lifted out, or the mold may be upset and the ingot dumped, whichever method is most suitable to the individual plant."

A typical Gathmann Big-End-Up Mold and Feeder is depicted below and is made for the production of ingots having a cross-section of from 5 inches by 5 inches to 24 inches by 24 inches; in weight, from 150 to 12,000 lb. per ingot.



"This ingot mold has a cavity 7 inches square at its lower end and 9 inches square at the upper end. The lower mold wall is 4¾ inches thick, while at its upper end it is only 2½ inches thick. These ingot dimensions and mold wall thicknesses give a freezing ratio for this mold of approximately 6 to 1, or, in other words, the mold per cubic inch of ingot considered absorbs heat six times more rapidly at the lower end than at its upper end, with intermediate values of heat absorption between these points. This large freezing ratio is necessary for ingots with a high ratio of length to diameter. The lower end of the ingot is necked in and formed by a compound curve ending in a flat bottom or plate recess, thus effectively preventing cleavage cones and butt cracks.

"The bottom of the mold is closed by a conical closing and stripping plug, the lower portion of which projects below the mold bottom, to be used as an ingot ejector when necessary. Above the plug, and fitting closely in the chamber bottom, a plate recess is provided, the function of which is to protect the bottom of the mold chamber against erosive wear and prevent the sticking of the plug to the ingot. The plate itself welds fast to the bottom of the ingot and is cropped therewith.

"The sinkhead or refractory top shown is designed to be placed on the molten steel as soon as the mold is filled to its desired height, and then itself poured full. This method of hot-topping is the standard old dozzle practice of crucible steel makers, the advantage of this type of hot-top being that part of the shrinkage of the ingot takes place before the sinkhead is filled.

"It is difficult in large ingots to perform the timing operation correctly and in these a sinkhead is placed on top of the mold, through which the steel is poured for the entire ingot. The hot-top for all molds should be so constructed or equipped that hanging of the ingot in the top will not occur, as this hanging is apt to impede free shrinkage of the solidifying ingot structure. . . .

"The yield of sound steel obtainable from ingots of this type and size is dependent mainly on the segregation range permissible within the ingot and the workmanship or skill with which the various operations are carried out.

"For ingots from 5 inches square to 12 inches square there is little carbon segregation, the solidification taking place so rapidly that the dendrites entangle the segregates before they have a chance to emigrate and cool in clots. The yield in actual practice is somewhere between 85 and 90 per cent of the ingot weight for the sizes of ingots mentioned. For larger ingots the yields are dependent on these same factors, in addition to which the type and heat efficiency of the sink-head largely enter. The yields obtainable here range from 80 to 85 per cent of the ingot weight, being less as the size and weight of the ingot increases. . . .

"The only change involved in the use of the ingot with its large end up instead of with its large end down (at present the general practice) is to lift the ingot out of the mold instead of lifting the mold off the ingot. . . . The employment of the Fundamentals Essential to Soundness does not necessarily involve the disuse of any material part of the present equipment of our steel mills nor the obtaining of any great amount of additional equipment.

"The changes involved do not have to be made all in one day, but can be made in a reasonable time, without interfering with present-day operations. . . ."

The patents of the Gathmann Engineering Company cover the shape of the ingot chamber, closure and seal of the bottom of the mold, stripping plug and means for ejecting the ingot, refractory hot tops and certain other details that have been found workable in casting big-end-up ingots. It is stated that the use of these molds and sink-heads does not require the disuse of any substantial part of present equipment, nor investment in new equipment other than the molds and sinkheads, and the company claims that large plants set up for teeming on cars can make all necessary changes without interfering with present-day operations.

The price of the refractory sink-head varies from 25 cents per ton of ingot for large ingots to $1.00 per ton of ingot for those of small dimension. It is presumed that it is the company's thought that transitional replacement obviates extra initial investment in the molds, though relative prices of Gathmann and ordinary molds are not quoted.

The Gathmann process has been used for a number of years for making steel for forging purposes, but until quite recently, it is believed, that this method has not been applied to any extent to rail making. In July of 1926 the Carnegie Steel Company agreed to roll at the Edgar Thomson Plant 500 tons of rail for the Baltimore and Ohio Railroad Company under the supervision and according to the direction of representatives of the Gathmann company. This rail, together with equal quantities of Railroad specification rail and Special rails that the Carnegie Steel Company offered to furnish were to be laid in track and be observed. The so-called Special rails were made according to standard specifications, but with a sufficient discard to eliminate the "A" rails. Representatives of the steel company claimed that cropping below the "A" rail would give as sound steel as the Gathmann sink-head method.

To propitiously provide for the casting of the Gathmann ingots a meeting was held April 23, 1926, at which were present representatives of the Railroad, Steel and Gathmann companies and the following principles were agreed upon:

The Steel Company to:

(1) Bring bath of molten metal to suitable chemical condition to meet specifications regarding sulphur and phosphorus.
(2) Have carbon and residual manganese not under 0.30 each, before any finishing additions are made in the furnace.
(3) Add sufficient 0.12, 0.15 or 0.18 ferro-silicon to thoroughly deoxidize the bath.
(4) Recarburize bath 10 to 15 minutes after adding silicon and add final manganese immediately thereafter.
(5) Specify amount of hot iron to be added; aiming at 0.70 carbon.
(6) Add in ladle only final silicon to meet specifications and 12 ounces of aluminum per ton of steel when ladle is one-third full, and these additions to be completed when ladle is two-thirds full.
(7) Steel in ladle to analyze:

Carbon	0.62 to 0.77	aiming at 0.68
Manganese	0.70 to 1.00	aiming at 0.85
Silicon	0.15 to 0.30	
Phosphorus	under 0.04	
Sulphur	under 0.05	

(8) Keep ingots in molds about 2½ hours or until completely solidified. Designate where ingots are to be stripped. Lay ingots on their sides on the cars. Charge in soaking pits quickly after stripping. Place in pits with sinkhead down so that discard portion will rest on pit bottom. Determine the proper rolling temperature.

Bloom, boost the bloom temperature and roll into rails in accordance with the Steel Company's practice. Add special Gathmann identification mark in addition to the usual branding.

(9) Make these experimental heats in same furnace during day time and, if possible, by same crew.
(10) Give check tests of all melts and test sections of top, middle and bottom croppings of any bloom or rail to Gathmann representatives when required.
(11) Make from first heat, before further heats are made, one ingot in a regular type mold and one in a Gathmann mold, if agreeable to Steel Company, to be split and examined and a chemical survey made under Gathmann direction. Both sections of split ingots to be property of the Gathmann Company.

The Gathmann Engineering Company to:

(1) Pass on slag condition and temperature of the bath.
(2) Pass on deoxidation of bath.
(3) Ingots to be designed to produce four 39-foot 100.5-lb. rails. Ingot with sinkhead will weigh about 6700 lb. Two blooms must weigh 5600 lb.
(4) Have the right at all times to inspect the making of the steel and to supervise the finishing of the bath.
(5) Have the right to be present at all physical tests of specimens, including drop tests.

The ingot molds were 66 inches high, 19 inches by 19 inches at the bottom and 22 inches by 22 inches at the top, inner dimensions. They had a wall thickness of 7½ inches at the bottom and 5 inches at the top The sinkhead was 17 inches by 17 inches inside and 17 inches high, set

3 inches down in the ingot mold, so that the overall height of ingot and top was 80 inches. The metal contained in the sinkhead was about 14½ per cent of the total. Carnegie standard ingot dimensions were 23½ inches by 23½ inches at the bottom, tapering in a height of 76 inches to 21½ inches by 21½ inches at the top.

Additional time and labor were required for stripping and transfer of the ingots due to the fact that the plant was not equipped to perform with facility these operations with this type of ingot. Also, in taking the ingots from the soaking pits where they had been placed top down, additional work was required to reverse them so that the top end would go through the blooming rolls first. At the Carnegie plant it is the practice to give the first two passes in the blooming mill top end first and then to reverse the mass of metal so that the bottom discard is made first at the bloom shares.

The results of the various heats have been described by W. C. Barnes, Engineer of Tests, Rail Committee, A.R.E.A., and are here quoted from his paper dated October 19, 1926.

"The first heat, number 209248, was made on July 12 under the specifications above mentioned, and the test ingot analysis is as follows: C .62, Mn .73, Phos .047, Sul .050, Si .15.

"This heat was rejected on account of the high phosphorus which reverted from the slag to the metal toward the end of the heat.

"This may have been caused by the recarburization being done in the furnace in the presence of a basic slag, which would permit the carbon, silicon and manganese of the recarburizer to reduce the phosphorus from the slag. The pre-test before tapping showed .017 phosphorus. The sulphur on pre-test showed .05, which may have been caused from high sulphur hot metal. The Gathmann people claim that this heat was not made according to their Specifications on pre-manganese in the bath and was much too hot, the high temperature together with the low residual manganese of only .16 and a considerable delay in tapping resulting in the off heat.

"Many fins formed in the teeming of the ingots, which prevented the removal of the 1 inch blocks, hereinafter described, from under the sinkhead. This resulted in many hanging cracks on the ingots.

"Ingot No. 32 of this heat was split for examination and analysis and showed a depth of pipe of only about 12 inches from the top of the sinkhead, the remaining metal being sound."

One ingot of this heat was rolled into rails and these were seamy and flawed. Nine test pieces were made from the top rail numbered 1 to 9 from the top and subjected to the drop test. No. 1 broke under the first blow and showed pipe, the other 8 pieces withstanding the test. On nicking and breaking these pieces 2, 3, 4, 5 and 6 showed segregated material; 7 and 8 did not. The top discard was 12 per cent.

"Heat Number 203284, July 18, 1926.

"This and the following heats were made by the usual practice of the Carnegie Company, which consisted of recarburizing with 5 per cent cupola (spiegel) in the ladle. The only exception to this practice was that ladle additions were made of about 100 lb. of extra ferro-silicon (50 per cent) and 110 lb. of aluminum.

"In this heat there was considerable difficulty in bringing down the carbon and 13 hours were required for the heat. On this pouring the sinkheads were raised about 2½ inches. This heat was poured in good order. The 39 Gathmann molds required 51 minutes for teeming. This teeming was performed by pouring a mold to the shoulder and stopping, then pouring the next mold to the shoulder and stopping, then pouring the sinkhead of the previous mold, etc. The stripped ingots had a very good appearance and were relatively free from hanging cracks owing to the proper removal of the 2½-inch blocks after teeming.

"Height of pour—2 inches below top.

"Analysis—C .74, Mn .78, Phos .040, Sul .065, Si .22.

"Time of heat.—This heat was what is termed a 'soaker'; that is, a heat which is started Saturday and remains in the furnace until one or two o'clock P. M. Sunday.

"Time of pouring—approximately 51 minutes.

"Time between pouring and charging—4 hrs. 25 min.

"Time between charging and drawing—4 hrs. 35 min.

"Time of rolling—3 hrs. 30 min.

Distribution of the Metal From the Ingots

Ingot Number	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Total ingot weight, lb.	6830	6925	6785	6865	6925	6705	6770
Top discard including sink-head, lb.	1325	1445	1260	1350	1320	1130	1285
Per cent	19.4	20.9	18.6	19.7	19.1	16.8	19.0
Bottom discard, lb.	175	150	190	175	255	235	165
Per cent	2.6	2.2	2.8	2.6	3.7	3.5	2.4
Per cent total discard at shears	22.0	23.1	21.4	22.3	22.8	20.3	21.4
Blooms for 4-39′ 100-lb. rails, lb.	5330	5330	5335	5340	5350	5335	5320
Per cent	78.0	76.9	78.6	77.7	77.2	79.7	78.6

Inspection

Ingots rolled	36	Second quality rails	70
Rails rolled	144	Scrap	3
First quality rails	54	Number rails shipped	54
Cut off rails	22		

The first rail from all Gathmann ingots was lettered "B."

"Only 39 ft. rails shipped, all 'B' rails which were to be cut 33 ft. long classed second quality account flaws.

Drop Test Results

Heat	*Test Ingot*	*Perm't Set*	*Elongations*	*No. of Blows*	*Fract*
203284	2	1.20		1	
		2.10		2	
		3.10	.07 .08 .09 .08 .07	3	
		Twisted N. & B.		4	O. K.
	18	1.20		1	O. K.
	36	1.20		1	O. K.

"At the time of this rolling the Gathmann people were of the opinion that the high sulphur content, namely .065, was in some degree responsible for the large number of seconds. The results, however, of the later rollings indicated that this was not the real cause, which is now claimed to be due to the cross-section of the Gathmann ingot being too small to obtain the proper amount of reduction in the first blooming mill rolls. The defects in the Gathmann rails which classed them as second quality consisted principally of seams in the heads, slivers and arrow heads in the head, web, flange and base.

Heat Number 203286, July 19, 1926

Sinkheads raised 2½ inches from molds.
Height of pour—4 inches from top.
Temperature about right.
The teeming of this heat was considered good and the resulting ingots showed smooth surfaces free from splashes and hanging cracks

Analysis—C	.72
Mn	.82
Phos	.018
Sul	.043
Si	.20
Time of heat	9 hrs. 50 min.
Time of pouring	0 hrs. 54 min.
Time between pouring and charging	5 hrs. 0 min.
Time between charging and drawing	4 hrs. 45 min.
Time of rolling	0 hrs. 50 min.

Distribution of Metal From the Ingots

Ingot Number	*2*	*5*	*8*
Total ingot weight, lb.	6895	6715	6645
Top discard including sink-head, lb.	1365	1165	1090
Per cent	19.8	17.3	16.4
Bottom discard, lb.	195	205	200
Per cent	2.8	3.1	3.0
Per cent total discard at shears	22.6	20.4	19.4
Blooms for 4-39′ 100-lb. rails, lb.	5335	5345	5355
Per cent	77.4	79.6	80.6

Inspection

Ingots rolled	35	Second quality rails	115
Rails rolled	140	Scrap	0
First quality rails	19	Number rails shipped	19
Cut off rails	4		

"Only 39 ft. rails shipped, all 'B' rails which were to be cut 33 ft. long classed second quality account flaws.

Drop Test Results

Heat	*Test Ingot*	*Perm't Set*	*Elongations*	*No. of Blows*	*Fract.*
203286	18	1.10		1	
		2.00		2	
		2.90	.07 .10 .11 .11 .10 .07	3	
		Twisted N. & B.		4	O. K.
	35	1.10		1	O. K.
	2	1.10		1	O. K.

Heat Number 206264, July 20, 1926

Sink-heads raised 2½ inches from molds.
Height of pouring 4 inches from top.
Temperature very good.
Teeming of this heat was considered good and the resulting ingots showed smooth surfaces comparatively free from splashes and hanging cracks.

Analysis—C ..... .74
Mn ..... .76
Phos ..... .020
Sul ..... .024
Si ..... .22
Time of heat.....9 hrs. 30 min.
Time of pouring.....0 hrs. 50 min.
Time between pouring and charging.....3 hrs. 30 min.
Time between charging and drawing.....4 hrs. 0 min.
Time of rolling.....1 hr. 10 min.
Top discard.....17 per cent
Bottom discard.....3.5 per cent

Inspection

Ingots rolled	34	Second quality rails	85
Rails rolled	136	Scrap	6
First quality rails	33	Number of rails shipped	33
Cut off rails	8		

Only 39 ft. rails shipped, all "B" rails which were to be cut 33 ft. long classed second quality account flaws.

Drop Test Results

Heat	*Test Ingot*	*Perm't Set*	*Elongations*	*No. of Blows*	*Fract.*
206264	2	1.10		1	
		2.00		2	
		2.90		3	
		Twisted N. & B.		4	Piped
	17	1.20		1	
		2.20		2	
		3.15	.07 .08 .10 .10 .08 .07	3	
		Twisted N. & .B		4	O. K.
	33	1.20		1	

Rolling Discontinued

Because of the high percentage of seconds with the Gathmann rails, the attendant loss of time and money, and the interference with the regular schedule of rollings it was agreed that the test be discontinued. The Railroad, the Steel Company and the Gathmann Engineering Company agreed that sufficient rails were at hand for the experiment.

Test in Track

"The three Gathmann heats produced 106-39 ft. rails for the Baltimore & Ohio Railroad. These rails will be laid in groups of ten (five on each side of track) with the standard rails and with the 40 per cent top discard titanium-treated rails. It has been decided that the location of this one and one-quarter mile test track will be between Pittsburgh and New Castle, both on curve and on tangent track.

Acknowledgment

"Acknowledgment is due to C. P. VanGundy, Engineer of Tests of the Baltimore & Ohio Railroad and to Emil Gathmann, President of the Gathmann Engineering Company, for their courtesy in furnishing the writer with the data embodied in this report.

Remarks

"In the absence of comparative tests of Gathmann and standard ingots and rails, the relative quality of the rails from the same portion of the ingot is unknown. The results of service tests will be of great interest.

A

"In general, the fractures of the test rails looked very good, however it will be noted that the 'B' rail from Ingot No. 2 of Heat No. 206264 showed a piped fracture notwithstanding a top discard of 17 per cent had been made.

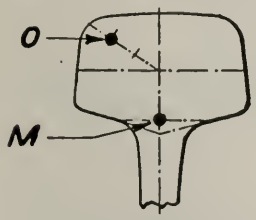
"The large percentage of second quality rails due to surface defects may have been caused by the Gathmann ingots entering the first blooming mill rolls, large end first.

"The efficiency of these Gathmann ingots as represented by the percentage of total ingot metal available for rails varied from 76.9 per cent to 80.6 per cent as compared with a typical efficiency of about 84 per cent for Carnegie's Standard Ingot."

There were 420 rails rolled, of which 106 or 25 per cent were accepted as No. 1. The major cause for criticism of the rails after the Carnegie Company's steel was used seems to have been their surface imperfections. These were not directly due to the use of the sink-head principle, though it is possible that they may be ascribed indirectly to it, since, as practiced by the Gathmann Company, it actuated the requirement of holding the ingot in the mold until complete solidification had taken place, about 2½ hours. This interval, combined with the delays in stripping and transferring, constituted an unusually long time between the teeming operation and charging in the pits, thus permitting the ingots to cool to a temperature too low to be reheated properly in the time allowed.

In 1914 the Pennsylvania Railroad Company prepared revised specifications, dated February 24, 1914, and known as 1914 (6th proof), for 100-lb. O.H. P.S. rail that were much more exacting in their requirements than any that had been issued previously in that they provided, inter alia, that the chemical composition of the steel would be determined by analysis of drillings taken from point "O" of the finished rail, and that the amount of carbon at point "M" should not vary more than 12 per cent plus or minus from that found at "O." If the test of the "A" rail failed to meet this requirement, all of the "A" rails of the heat were to be rejected and the "B" rail was to be tested. If it failed, the "B" rails of the heat were to be discarded and the "C" rail tried. Its failure would throw out the entire heat.

The specifications of 1912 and those known as 1914 (revision of 1912) dated June 12, 1914, the latter being those under which a large part of the 1914 rail eventually was rolled, permitted the determination of the chemistry of the steel from the ladle test ingot. Carbon segregation had not before been controlled by the specifications.



The steel, as represented by drillings from point "O", was to contain:

Carbon	0.60 to 0.75
Phosphorus not to exceed	0.04
Manganese	0.60 to 0.90
Silicon	0.05 to 0.25

Before adopting these specifications it was considered best that a manufacturing test should be made of them to determine their practicability and to obtain information concerning the additional expense

involved as compared with the 1912 specifications. To this end, orders for 10,000 tons each were placed with the Pennsylvania and the Cambria Steel Companies, 5,000 tons to be rolled under the 1912 specifications, modified to the extent that all three test pieces must pass the drop test instead of two out of three, and 5,000 tons under the 1914 (6th proof) specifications.

The price for No. 1 rails under the 1912 specifications revised was $30.80 per gross ton, made up as follows:

Base, O.H. steel	$30.00
Older specifications had allowed acceptance of top rails as "Special" rails in case the top rail test piece, when nicked and broken, showed pipe. Elimination of "Special" rails	.55
Requiring all three test pieces to pass drop tests instead of two out of three	.25
	$30.80

The price for the rails under the 1914 specifications was to be this price of $30.80 plus the extra mill cost of their manufacture. This arrangement resulted in a price of $32.05 for the 1914 specification rails.

Considerable difficulty was experienced in meeting the 1914 specifications, both at the plant of the Maryland Steel Company at Sparrow's Point, where the Pennsylvania Steel Company order was rolled, and at the Cambria plant at Johnstown. It was found in some cases that the "A" rail would show less than 12 per cent segregation while the "B" rail, or, in cases, the B and C rails, showed considerably more than this amount. At the Cambria plant three sizes of ingot molds were used, 19 inches by 23 inches, 23 inches by 28 inches and 25 inches by 30 inches and it was naturally suspected that segregation might be found as far down as the "C" rails in the case of the large ingots. For this reason segregation tests were made of all three test pieces, and, as a result the use of the 25 inch by 30 inch molds eventually had to be discontinued. Of the 111 heats rolled, 63 heats were defective in one way or another.

For some time the Cambria Company had been making experiments along the line suggested by Sir Robert Hadfield in an earnest endeavor to develop a practical means of casting sound ingots that would be consistent with the demands of American production, and, since the results of the trial order of 1914 specification rail were not such as to arouse great enthusiasm, Mr. Kenney suggested that the specifications might best be complied with by use of the sink-head method. Accordingly, an additional order for 5,000 tons of 1914 (6th proof) rail was given this company.

They agreed to furnish this rail rolled from ingots cast in large end up molds equipped with sink-heads, for $33.80 per gross ton, and further agreed, in order to determine that all of the rails were uniform and free from segregation with greater certainty than might be possible by the requirements of the 1914 (6th proof) specifications, to meet segregation tests of the "B" and "C" rails even though the "A" rails passed. Segregation in excess of 12% in the "B' rail was to reject the "A" and "B" rails of the heat and segregation found in the "C" rail beyond this amount was to cast out the entire melt.

At first glance, and in view of the results of the trial order of 1914 rail, these provisions would appear to be very exacting and of a severity sufficient to cause the rejection, perhaps, of a great number of heats. When consideration is given, however, to the principles of the process, hereinbefore set forth, that piping steel is used and the pipe confined to the sink-head, that segregation is reduced to a minimum in quieted steel, is greatest in the metal last to freeze, and that the large-end-up mold insures progressive freezing, thus making the top the last to solidify, it will be realized that there were good reasons for the anticipation of a successful meeting of the requirements.

As a matter of fact, there was only one case of rejection for segregation in the entire 5,000 tons, the "A" rails of one heat. In this heat, 93010, the "A" segregation was 17.05 per cent, "B" 5.69 per cent and "C" 2.19 per cent. The details of the chemical tests are set up in Appendix A.

Considerable piping, however, was in evidence, the "A" rails of 32 heats being rejected for this cause and in two of these heats both the "A" and "B" rails were affected. But these results should not be taken exactly at their face value since the sink-head method at the Cambria plant was in the experimental stage, and the size of top necessary to confine the cavity within it without applying external heat was more or less a matter of trial. The preponderance of the piping in this rolling occurred in the earlier heats when the tops were too small. After changing to larger sinkheads this evil was very materially reduced. Then again, some of the tops were of firebrick and some were loam and the poorer insulating qualities of the former may have permitted more metal to freeze around the sides, leaving an insufficient quantity to flow into the ingot.

For purposes of comparison there follows a summary of the rollings at the Cambria plant of the 1914 (6th proof) specification rail by the ordinary and by the sink-head methods.

	Ordinary Practice	Sink-head Method
Tonnage ordered	5,000	5,000
Top Discard	16%	14.8%
Bottom Discard	4.7%	3.2%
Heats rolled	111	106
Rejections:		
Heats, High carbon	2*	1
Heats, Low carbon	3†	..
Heats, Low manganese	1	1
Heats, Piping. A rails	21‡	30
Heats, Piping. B rails of A and B (A rails incl. above)	5	2
Heats, Segregation		
A rails	35§	1
B rails of A and B (A rails incl. above)	4	..
B rails, A rails not	5¶	..
B rails of B and C (A rail piped)	1	..
C rails of B and C (A rail piped)	1	..
Heats, Breaking under drop test A rails	5°	1
Heats defective	63	36

*A rail of one heat also piped. †B rail, but not A rail, of one heat also segregated. ‡B rails of 5 heats also piped; one heat also high carbon. §Of these also: A rails 3 heats piped, A rail 4 heats broke under drop, B rails 4 heats segregated. ¶Of these, 1 heat rejected low carbon. °A rails of 4 of these segregated.

Carbon Segregations in A Rails, Cambria Rollings

	Ordinary	Sink-head
Heats rolled	111	106
Heats segregated more than 12 per cent, positive	35	1
Heats showing positive segregation	104	75
Average segregation of all heats with positive segregation	11.1%	5.0%
Average segregation of heats over 12 per cent, positive	18.3%	17.1%
Average segregation of heats under 12 per cent, positive	7.4%	4.8%
Maximum segregation	37.8%	17.1%
Heats segregated 12 per cent to 15 per cent	11	..
Heats segregated 15 per cent to 20 per cent	12	1
Heats segregated 20 per cent to 25 per cent	9	..
Heats segregated 25 per cent to 30 per cent	2	..
Heats segregated more than 30 per cent	1	..

Rejections in the Two Cambria Rollings

	1914 (6th Proof Specifications)					
	Ordinary Practice			Sinkhead Method		
	Tons	Rails	%	Tons	Rails	%
Total rolled	6016	12154	100	5877	11856	100
Rejections						
Piping A rails	210	424	3.5	356	713	6.0
" B rails	48	98	0.8	26	53	0.5
" Total	258	522	4.3	382	766	6.5
Chemical Composition—High Carbon	89	180	1.5	55	109	0.9
" " —Low Carbon	171	346	2 8	0	0	0
" " —Low Manganese	51	103	0.9	61	121	1.0
" " —Total	311	629	5.2	116	230	1.9
Breaking under drop test A rails	53	107	0.9	13	25	0.2
Segregation A rails	330	667	5.5	13	26	0.2
" B rails	84	170	1.4	0	0	0
" C rails (and heat)	53	107	0.9	0	0	0
" Total	467	944	7.8	13	26	0.2
Surface Imperfections	395	797	6.6	596	1192	10.1
Total Rejections	1484	2999	24.7	1120	2239	18.9
Put in Stock	36	70	0.6	3	6	0.1
Accepted No. 1	4243	8573	70.1	4503	9105	76.8
" No. 2	253	512	4.2	251	506	4.2
" No. 1 under 1912 specifications	(534)	(1090)	....	(103)	(207)	....
Total Accepted	4496	9085	74.7	4754	9611	81.0

Chemistry of Accepted Rail

	Maximum		Minimum	
	Ordinary	Sinkhead	Ordinary	Sinkhead
Manganese	0.90	0.86	0.60	0.59
Phosphorus	0.040	0.040	0.011	0.011
Silicon	0.175	0.226	0.010	0.067
Carbon AO	0.749	0.756	0.604	0.600
Carbon AM	0.838	0.800	0.602	0.596
Carbon BO	0.745	0.761	0.607	0.606
Carbon BM	0.839	0.784	0.594	0.596
Carbon CO	0.749	0.764	0.604	0.600
Carbon CM	0.791	0.774	0.591	0.574

The average composition of the heats was

	Ordinary	*Sink-Head*
Manganese	0.73	0.74
Phosphorus	0.025	0.023
Silicon	0.098	0.140
Carbon AO	0.67	0.67

Drop Tests. (2000 Tup Dropping 18 Feet)

	No. of pieces tested	Permanent Set in inches 1st Blow			Maximum Elongation per cent in 1 inch 1st Blow		
		Max.	Min.	Avg.	Highest Maximum	Lowest Maximum	Avg. of the Max.
1914 (6th proof) Spec. Ordinary practice...	333	1.5	0.8	1.2	0.07	0.01	0.05
1914 (6th proof) Spec. Sink-head method..	396	1.5	1.1	1.3	0.07	0.02	0.04

In addition to the heat number, the rails made by the sink-head method were also stamped S.H. for identification. They were distributed to the divisions in the following amounts.

New York	390 tons	2.3 track miles
Philadelphia	500 tons	3.1 track miles
Middle	800 tons	5.0 track miles
Conemaugh	600 tons	3.8 track miles
Monongahela	400 tons	2.5 track miles
Williamsport	979 tons	6.2 track miles
Renovo	405 tons	2.6 track miles
Philadelphia terminal	680 tons	4.3 track miles
	4.754 tons	29.8 track miles

There have been 71 failures in the sink-head rail and 72 failures in the 1914 specification ordinary rail.

Failures to October 31, 1926, in 1914 (6th Proof) Specification Rail Rolled by Cambria Steel Co.

	1914 (6th proof) Specification			
	Ordinary Practice		Sinkhead Method	
Tons ordered	5000		5000	
Tons accepted No. 1	4243		4503	
Tons accepted No. 2	253		251	
	4496		4754	
	Number	per 1000 tons	Number	per 1000 tons
Transverse Fissure	8	1.8	*11	2.3
Broken Rails	23	5.1	*24	5.1
Flow of Metal	5	1.1	3	0.6
Crushed Head	11	2.5	4	0.8
Split Head	2	0.4	15	3.2
Split Web	23	5.1	*13	2.7
Broken Base	..	0.0	1	0.2
Total	72	16.0	71	14.9

*In addition 1 transverse fissure, 1 broken rail and 1 split web occurred in the 103 tons of Sink-head rail that failed to pass the 1914 (6th proof) specifications and were accepted under those of 1912.

Transverse Fissures in Sink-Head Rail

4 or 36.4% occurred on tangent track
4 or 36.4% occurred on inside rail of curves
2 or 18.1% occurred on outside rail of curves
1 or 9.1% occurred on curve not recorded in or out.
11 or 100%

1 or 9.1%, A rail	
3 or 27.3%, B rails	5 on Middle Div.
2 or 18.1%, C rails	2 on Williamsport Div.
1 or 9.1%, D rail	2 on Philadelphia Div.
1 or 9.1%, G rail	2 on Monongahela Div.
3 or 27.3%, not recorded	

None of these fissures occurred in joint. The average life of the rails that developed transverse fissures was 4.5 years.

Broken Rails in Sink-Head Rail

12 or 50% occurred on tangent track (9 in joint)
3 or 12% occurred on inside rail of curves (1 in joint)
1 or 5% occurred on outside rail of curves (in joint)
8 or 33% occurred on curves not recorded in or out (5 in joint)

5 or 20.8%, A rails	(2 in joint)
4 or 16.7%, B rails	(3 in joint)
6 or 25.0%, C rails	(5 in joint)
1 or 4.2%, D rail	(in joint)
3 or 12.5%, E rails	(2 in joint)
1 or 4.1%, H rail	(in joint)
4 or 16.7%, not recorded	(2 in joint)

8 on Philadelphia Div. (4 in joint)
4 on Monongahela Div. (all in joint)
10 on Renovo Div. (6 in joint)
2 on Conemaugh Div. (all in joint)

16 or 66% occurred in joint
8 or 33% occurred out of joint

The average life of these broken rails was 6.7 years.

All Other Failures

12 or 33% occurred on tangent track (9 in joint)
18 or 50% occurred on inside rail of curves (3 in joint)
6 or 17% occurred on curves not recorded in or out (5 in joint)

36

6 or 16%, A rails (1 in joint)
12 or 33%, B rails (5 in joint)
2 or 6%, C rails (1 in joint)
1 or 3%, D rail
6 or 16%, E rails (4 in joint)
1 or 3%, F rail
2 or 6%, G rails (2 in joint)
1 or 3%, H rail (1 in joint)
5 or 14%, not recorded (3 in joint)

36 17 or 47% in joint

The average life of all sink-head rail that failed was 5.7 years.

100 Lb. O. H. Rail Rolled by Cambria Steel Co. in 1914
Eastern Region Failures to October 31, 1926

	Tons Shipped	Failures						
		Broken Rails and Trans. Fissures	Head	Web	Base	Total		
						No.	Annual Average per 100 track miles	Per 1000 tons
1912 Specifications	2250	114	62	62	0	238	191	105.8
1912 Revised Specifications	3315	148	49	95	1	293	86	88.4
1914 (6th Proof) Spec. Ordinary Practice	2252	26	11	15	0	52	44	19.5
1914 (6th Proof) Spec. Sink-head Method	3349	17	19	9	1	46	39	11.6

Practically all of the 1914 ordinary and the 1914 sink-head rail has been removed from track.

About 80 per cent of the sink-head rail that was shipped reveals itself on forms M.W. 34-J. From these data an average life of 6½ years develops.

Early in 1917 the sink-head rail from the low side of the 6-degree curve at M.P. 169 on the Renovo Division was removed because of considerable wear. It had been in track 2.3 years and, when laid, replaced 85-lb. O.H. rail that was completely worn out after two years' service. The line at this point was single track with an 0.8% eastbound grade and the curve had a super-elevation of 6½ inches, for 40 m.p.h. Due to the sharpness of the curve and the heavy grade, movements were slowed up and considerable driver slipping occurred, producing rapid wear of the low rail.

Two four-foot pieces of this rail, being from heat 91710, were sent to the laboratory of the company for examination.

	Chemical Analysis		Analysis of heat when rolled	
	Point O	Point M	AO	AM
Carbon	0.645	0.618	0.633	0.645
Manganese	0.67	0.68	0.62	.....
Phosphorus	0.027	0.025	0.023	.....
Silicon	0.121	0.121	0.127	.....

Physical Tests of Rail Removed From Renovo Division

	Gage of Rail	Jct. of head and web
Tensile strength, lbs. per sq. in.	118,550	113,500
Elastic limit, lbs. per sq. in.	54,550	48,400
Elongation, per cent in 2 inches	14	14
Reduction of area, per cent of original section	21.9	19.2

The average Brinell hardness number was 235 and that of the Scleroscope, 36.

1915 Sinkhead Rail

In 1915 the Cambria Steel Company was given an order for 10,000 tons of 100-pound O.H rail to be made by the sink-head process and 12,350 tons by the ordinary method, both under the same specifications, 1915 (4th proof). The sink-head rails were not given any distinguishing characteristic and the only means of identification is by the heat numbers. The records present the following data regarding the rollings.

	Sinkhead	Ordinary
Top discard	18	23-26
Tons rolled	9350	16973
Tons accepted No. 1	8236	13068
Tons accepted No. 2	434	693
Tons put in stock	....	1547
Tons rejected	680	1665
Per cent rejected	7.3	9.8
Per cent accepted	92.7	81.1
Per cent put in stock	....	9.1
Tons rejected—Interior defect	202	905
Tons rejected—Segregation	202	45
Tons rejected—Chemical composition	53	45
Tons rejected—Surface imperfections	223	670

In the Eastern region the annual average number of failures per 100 track miles, to October 31, 1926, in 1915 (4th proof) 100-lb. Cambria rail is 29.4 in the sink-head and 52.9 in that rolled by the ordinary practice.

SUMMARY

	Ordinary Practice			Sinkhead Method		
	1914	1915	Total	1914	1915	Total
Tonnage Rolled	6016	16973	22989	5877	9350	15227
Heats Rolled	111	364	475	106	187	293
Top discard, percent	16	23-26	.....	14.8	18	.....
Top rail	A	B	.....	A	A	.....
Rejections						
Interior defect ....%	4.3	5.3	5.1	6.5	2.2	3.9
Segregation ....%	7.8	0.3	2.2	0.2	2.1	1.3
Chemical composition ....%	5.2	0.3	1.6	1.9	0.6	1.1
Broke under drop test ....%	0.9	0	0.2	0.2	0	0.1
Surface imperfections ....%	6.5	3.9	4.6	10.1	2.4	5.4
Total rejected ....%	24.7	9.8	13.7	18.9	7.3	11.8
Annual Average number of failures per 100 track miles to October 31, 1926, in the Eastern Region.	44	53	51	39	29	34

LOCATION OF TRANSVERSE FISSURE AND BROKEN RAIL FAILURES, THAT WERE NOT IN JOINT, IN ALL OF THE SINKHEAD RAIL ROLLED

	Rail						Not Recorded	Total	In Joint	Total
	A	B	C	D	E	G				
Trans. Fissures 1914 S.H.	1	3	2	1	0	1	3	11	0	11
Trans. Fissures 1915 S.H.	1	1	1	0	1	0	1	5	1	6
Broken 1914 S.H.	3	1	1	0	1	0	2	8	16	24
Broken 1915 S. H..	0	0	1	0	0	1	0	2	23	25
Total	5	5	5	1	2	2	6	26	40	66

The objective in the use of the sink-head method and the big-end-up mold is the production of an ingot of steel that requires less waste of material from the top, is denser and more homogeneous throughout, and, as a consequence, develops fewer failures in rail rolled therefrom, than an ingot made by the usual process.

Have these benefits been demonstrated in the trial rollings by the Cambria Steel Company? In a large measure, yes. Consider the total tonnage of the two years 1914 and 1915.

	Ordinary	*Sinkhead*
Top discard, weighted average	22.3%	16.8%
Per cent rejected of total rolled	13.7%	11.8%
Annual average failures in the Eastern region per 100 track miles	51	34

(1) The waste of material from the top was reduced by the sink-head method from 22 to 17 per cent and in addition rejections were fewer in this rail by 2 per cent.

(2) The annual average number of failures in sink-head rail per 100 track miles in the Eastern region was one-third less than the ordinary rail, or, 34 as compared with 51.

(3) If it may be assumed that the nuclei of transverse fissures are pipes, loose structure or foreign inclusions that cannot be obliterated in the rolling, it would seem that all of the ingots were not of perfect continuity throughout and free from these imperfections, for transverse fissures developed as far down as the G rail (table on page 30). There were, however, only 1.3 transverse fissures per 1000 tons of 1914 and 1915 sink-head rail, which may be compared with about 2.1 transverse fissures per 1000 tons of the same specification rail made by the ordinary practice, showing improvement.

Appendix A

CHECK ANALYSES ON RAILS ROLLED FROM SINK-HEAD INGOTS

Analyses marked "C" made by Cambria chemists, those marked "P. R. R." by Pennsylvania chemists.

Heat.		Analyses at point O of A Rail			CARBON DETERMINATIONS. A Rail			B Rail			C Rail		
		Si.	P.	Mn.	O.	M.	% Seg.	O.	M.	% Seg.	O.	M.	% Seg.
90,797	C	.198	.029	.74	.750	.778	3.73	.740	.770	4.06	.770	.750	—2.59
	P. R. R.	.193	.027	.75	.754	.794	5.31	.761	.784	3.02	.769	.760	—1.16
91,041	C	.124	.023	.65	.684	.756	10.52	.674	.676	0.30	.696	.660	—5.17
	P. R. R.	.138	.021	.63	.698	.773	10.73	.687	.673	—2.04	.671	.662	—1.34
91,058	C	.136	.040	.72	.668	.672	0.60	.686	.690	—0.59	.680	.690	1.48
	P. R. R.	.150	.038	.70	.667	.676	1.35	.701	.709	1.15	.703	.710	1.00
91,075	C	.225	.029	.83	.738	.745	0.96	.746	.730	—2.15	.754	.744	—1.33
	P. R. R.	.203	.028	.79	.738	.753	2.03	.736	.725	—1.50	.742	.734	—1.08
91,105	C	.135	.028	.74	.727	.700	—3.71	.700	.675	—3.56	.700	.690	—1.42
	P. R. R.	.141	.025	.76	.738	.689	—6.64	.710	.669	—5.77	.687	.698	1.60
91,126	C	.099	.019	.60	.676	.698	3.26	.666	.664	0.30	.668	.650	—2.69
	P. R. R.	.094	.020	.61	.689	.675	—2.03	.680	.667	—1.91	.667	.636	—4.65
91,139	C	.078	.020	.74	.640	.640	0	.620	.620	0	.646	.600	—7.11
	P. R. R.	.077	.020	.71	.638	.636	—0.31	.627	.596	—4.94	.640	.605	—5.47
91,182	C	.142	.023	.77	.670	.700	4.48	.678	.694	2.38	.676	.708	4.75
	P. R. R.	.165	.021	.82	.639	.671	5.01	.658	.683	3.80	.684	.686	0.29
91,202	C	.101	.019	.63	.722	.713	—1.24	.710	.700	—1.41	.700	.700	0
	P. R. R.	.120	.017	.63	.705	.714	1.28	.680	.693	1.91	.680	.691	1.62
91,271	C	.138	.020	.74	.688	.679	—1.30	.674	.728	8.01	.710	.704	0.84
	P. R. R.	.165	.019	.72	.691	.673	—2.60	.696	.708	1.73	.679	.694	2.21
91,301	C	.141	.022	.77	.707	.773	9.33	.720	.740	2.78	.734	.714	—2.72
	P. R. R.	.152	.022	.73	.714	.754	5.60	.747	.733	—1.87	.720	.722	0.28
91,319	C	.133	.024	.70	.661	.708	7.10	.700	.710	1.43	.664	.700	5.42
	P. R. R.	.136	.023	.70	.669	.693	3.58	.678	.681	0.45	.676	.698	3.27
91,371	C	.125	.022	.69	.667	.713	6.88	.662	.670	1.21	.684	.640	—6.43
	P. R. R.	.130	.022	.67	.671	.707	5.36	.634	.674	6.31	.667	.625	—6.30
91,396	C	.041	.017	.66	.610	.628	2.95	.614	.638	3.91	.618	.638	3.23
	P. R. R.	.067	.016	.64	.600	.596	0.68	.606	.618	1.97	.595	.631	6.04
91,442	C	.147	.017	.59	.671	.644	—4.12	.660	.630	—4.54	.660	.610	—7.57
	P. R. R.	.144	.016	.60	.680	.629	—7.50	.669	.634	—5.24	.660	.604	—8.48
91,465	C	.078	.023	.80	.730	.755	3.43	.760	.740	—2.63	.754	.740	—1.85
	P. R. R.	.080	.023	.76	.744	.760	2.16	.745	.735	—1.34	.733	.735	0.28
91,480	C	.104	.018	.68	.625	.627	0.32	.628	.620	—1.27	.608	.640	5.28
	P. R. R.	.125	.019	.68	.625	.651	4.16	.658	.643	—2.27	.636	.640	0.63
91,490	C	.110	.022	.70	.655	.715	9.17	.650	.664	2.17	.650	.646	—0.61
	P. R. R.	.120	.020	.69	.663	.715	7.84	.660	.660	0	.647	.650	—0.47
91,517	C	.121	.023	.68	.656	.633	—3.50	.660	.660	0	.660	.664	0.61
	P. R. R.	.141	.020	.71	.669	.622	—7.03	.638	.645	1.10	.680	.653	—3.96
91,527	C	.103	.024	.71	.645	.610	—5.43	.665	.590	—11.28	.650	.600	—7.69
	P. R. R.	.101	.022	.68	.627	.596	—4.94	.681	.605	—11.16	.642	.598	—6.85
91,539	C	.101	.020	.71	.649	.713	9.87	.660	.710	7.58	.652	.640	—1.82
	P. R. R.	.100	.018	.71	.656	.722	10.70	.682	.720	5.58	.647	.638	1.39
91,551	C	.151	.024	.75	.698	.723	3.59	.684	.700	2.36	690	.690	0
	P. R. R.	.165	.024	.73	.665	.736	10.68	.688	.671	—2.46	.673	.664	—1.33
91,559	C	.073	.023	.73	.669	.712	6.42	.646	.650	0.62	.660	.664	0.61
	P. R. R.	.078	.023	.72	.676	.691	2.22	.669	.631	—5.68	.689	.673	—2.32
91,572	C	.180	.027	.78	.747	.748	0.13	.680	.694	2.07	.680	.660	—2.94
	P. R. R.	.179	.029	.76	.727	.727	0	.660	.676	2.42	.693	.682	—1.58
91,580	C	.200	.024	.74	.718	.720	7.23	.730	.760	4.11	.746	.760	1.87
	P. R. R.	.193	.023	.77	.732	.784	7.11	.719	.763	6.12	.733	.733	0
91,585	C	.183	.023	.76	.681	.678	—0.49	.674	.672	—0.30	.680	.688	1.18
	P. R. R.	.188	.024	.72	.667	.665	—0.30	.686	.647	—5.69	.694	.671	—3.31
91,599	C	.120	.025	.68	.648	.655	1.09	.670	.660	—1.49	.670	.650	—2.80
	P. R. R.	.120	.022	.68	.644	.642	—0.31	.689	.660	—4.21	.664	.651	1.96
91,611	C	.145	.016	.62	.661	.690	4.49	.688	.690	0.30	.686	.672	—2.03
	P. R. R.	.165	.015	.61	.674	.707	4.90	.665	.676	1.66	.669	.676	1.05

Heat.	Analyses at point O of A Rail	Si.	P.	Mn.	CARBON DETERMINATIONS. A Rail O.	A Rail M.	A Rail % Seg.	B Rail O.	B Rail M.	B Rail % Seg.	C Rail O.	C Rail M.	C Rail % Seg.
91,625	C	.140	.019	.71	.691	.753	8.96	.698	.692	—0.86	.688	.698	1.45
	P. R. R.	.162	.018	.70	.693	.749	8.08	.673	.674	0.14	.671	.682	1.64
91,640	C	.113	.024	.75	.663	.691	4.22	.662	.664	0.39	.680	.684	0:69
	P. R. R.	.125	.026	.73	.687	.670	—2.48	.665	.680	2.26	.665	.680	2.26
91,643	C	.137	.016	.67	.750	.772	2.92	.760	.778	2.37	.778	.760	—2.32
	P. R. R.	.145	.019	.64	.756	.751	—0.66	.752	.758	0.80	.745	.746	0.14
91,655	C	.113	.016	.68	.624	.673	7.85	.604	.600	—0.66	.600	.588	—2.00
	P. R. R.	.145	.013	.65	.630	.659	4.60	.614	.596	—2.92	600	.674	—4.32
91,661	C	.131	.020	.70	.761	.786	3.38	.744	.770	3.48	.740	.737	—0.40
	P. R. R.	.145	.019	.65	.744	.776	4.29	.749	.747	—0.26	.736	.774	5.17
91,666	C	.133	.018	.67	.735	.800	8.84	.748	.757	1.21	.740	.746	0.81
	P. R. R.	.148	.015	.70	.751	.800	6.52	.743	.742	—0.13	.743	.754	1.48
91,680	C	.122	.010	.63	.683	.727	6.44	.714	.730	2.23	.690	.685	—0.72
	P. R. R.	.112	.012	.63	.700	.747	6.70	.709	.727	2.65	.691	.711	2.90
91,710	C	.126	.022	.67	.658	.630	—1.22	.650	.650	0	.630	.646	2.53
	P. R. R.	.127	.023	.62	.633	.645	1.79	.644	.635	—1.40	.622	.629	1.13
91,717	C	.126	.019	.65	.675	.692	2.52	.680	.690	1.47	.686	.700	2.04
	P. R. R.	.112	.018	.65	.664	.685	3.16	.689	.689	0	.682	.685	0.43
91,720	C	.105	.010	.65	.638	.647	1.41	.640	.630	—1.56	.634	.640	0.95
	P. R. R.	.110	.011	.66	.636	.631	—0.78	.616	.649	5.37	.640	.652	0.88
91,739	C	.110	.020	.71	.680	.690	1.48	.680	.680	0	.670	.690	2.98
	P. R. R.	.125	.022	.73	.658	.669	1.68	.675	.694	2.82	.682	.665	—2.49
91,746	C	.136	.015	.69	.694	.685	—1.30	.702	.700	—0.29	.704	.680	—3.41
	P. R. R.	.153	.015	.69	.687	.707	2.61	.705	.709	0.57	.693	.698	0.72
91,750	C	.132	.017	.66	.702	.689	—1.86	.700	.718	2.57	.700	.704	0.57
	P. R. R.	.136	.015	.67	.694	.710	2.31	.694	.707	1.88	.685	.686	0.15
91,790	C	.155	.033	.78	.710	.741	4.37	.740	.782	5.68	.748	.776	3.74
	P. R. R.	.142	.034	.78	.702	.761	8.39	.731	.754	3.15	.729	.747	2.49
91,817	C	.141	.019	.75	.653	.655	0.31	.644	.668	3.73	.650	.660	1.54
	P. R. R.	.133	.021	.70	.662	.633	—4.38	.633	.653	3.17	.665	.658	—1.05
91,075	C	.225	.029	.83	.738	.745	0.96	.746	.730	—2.15	.754	.744	—1.33
	P. R. R.	.203	.028	.79	.738	.753	2.03	.736	.725	—1.50	.742	.734	—1.08
91,093	C	.105	.020	.75	.725	.710	—2.06	.690	.690	0	.710	.680	—4.22
	P. R. R.	.098	.024	.71	.710	.725	2.10	.694	.694	0	.696	.698	0.30
91,139	C	.078	.020	.74	.640	.640	0	.620	.620	0	.646	.600	—7.11
	P. R. R.	.077	.020	.71	.638	.636	—0.31	.627	.596	—4.94	.640	.605	—5.47
91,239	C	.129	.022	.73	.600	.650	8.31	.628	.640	1.90	.620	.630	1.61
	P. R. R.	.139	.020	.73	.593	.660	11.13	.641	.643	0.30	.623	.624	0.15
91,551	C	.151	.024	.75	.698	.723	3.59	.684	.700	2.36	.690	.690	0
	P. R. R.	.165	.024	.73	.665	.736	10.68	.688	.671	—2.46	.673	.664	—1.33
91,572	C	.180	.027	.78	.747	.748	0.13	.680	.694	2.07	.680	.660	—2.94
	P. R. R.	.179	.029	.76	.727	.727	0	.660	.676	2.42	.693	.682	—1.58
91,580	C	.200	.024	.74	.718	.720	7.23	.730	.760	4.11	.746	.760	1.87
	P. R. R.	.193	.023	.77	.732	.784	7.11	.719	.763	6.12	.733	.733	0
91,585	C	.183	.023	.76	.681	.678	—0.49	.674	.672	—0.30	.680	.688	1.18
	P. R. R.	.188	.024	.72	.667	.665	—0.30	.686	.647	—5.69	.694	.671	—3.31
91,640	C	.113	.024	.75	.663	.691	4.22	.662	.664	0.39	.680	.684	0.59
	P. R. R.	.125	.026	.73	.687	.670	—2.48	.665	.680	2.26	.665	.680	2.26
91,879	C	.162	.027	.84	.690	.700	1.45	.688	.730	6.10	.700	.706	0.86
	P. R. R.	.166	.030	.85	.698	.728	4.30	.719	.734	2.10	.711	.724	1.82
91,894	C	.109	.030	.79	.639	.641	0.32	.642	.652	1.57	.662	.664	—1.20
	P. R. R.	.122	.027	.75	.645	.652	1.09	.654	.650	—0.62	.654	.645	—1.38
91,902	C	.128	.021	.72	.683	.652	—4.53	.670	.660	—1.49	.680	.658	—3.22
	P. R. R.	.128	.018	.72	.676	.683	1.04	.702	.675	—3.84	.660	.678	2.73
91,916	C	.107	.018	.55	.680	.723	6.33	.700	.728	4.00	.668	.685	2.57
	P. R. R.	.114	.019	.55	.693	.729	5.21	.720	.725	0.70	.660	.691	4.70
91,938	C	.131	.018	.72	.649	.679	4.64	.656	.674	2.75	.640	.650	1.57
	P. R. R.	.128	.020	.74	.676	.680	0.59	.673	.680	1.04	.669	.671	0.31
91,953	C	.143	.018	.63	.710	.756	6.48	.700	.760	8.57	.700	.700	0
	P. R. R.	.145	.016	.65	.710	.745	4.94	.714	.763	6.87	.714	.690	—3.36
91,973	C	.175	.040	.81	.667	.702	5.25	.680	.694	2.37	.696	.680	—2.39
	P. R. R.	.197	.040	.83	.701	.701	0	.707	.701	—0.85	.700	.700	0
91,997	C	.233	.018	.71	.654	.690	5.50	.654	.684	4.59	.674	.686	1.78
	P. R. R.	.207	.016	.71	.678	.687	1.31	.685	.689	0.59	.673	.674	0.14
92,008	C	.174	.020	.70	.696	.733	5.32	.680	.718	5.58	.676	.664	—1.77
	P. R. R.	.163	.016	.70	.691	.740	7.08	.708	.731	3.27	.711	.667	—6.18
92,031	C	.190	.023	.84	.723	.786	8.71	.748	.740	—1.07	.750	.740	—1.33
	P. R. R.	.172	.021	.84	.744	7.69	3.37	.734	.762	3.83	.742	.740	—0.26
92,060	C	.170	.020	.75	.663	.730	1.01	.682	.684	0.30	.680	.708	4.11
	P. R. R.	.147	.021	.77	.690	.713	3.32	.696	.705	1.30	.671	.682	1.63
92,080	C	.146	.019	.75	.733	.772	5.32	.752	.750	—0.26	.740	.687	—7.16
	P. R. R.	.154	.021	.77	.745	.783	5.08	.753	.770	2.26	.751	.720	—4.13
92,098	C	.114	.014	.63	.638	.694	8.77	.656	.670	2.14	.646	.670	3.72
	P. R. R.	.132	.013	.61	.656	.702	7.02	.662	.669	1.07	.645	.642	—1.46
92,117	C	.126	.026	.71	.709	.725	2.25	.700	.700	0	.720	.706	—1.94
	P. R. R.	.141	.028	.71	.730	.714	—2.19	.729	.713	—2.19	.707	.729	3.10
92,135	C	.142	.017	.64	.720	.755	4.87	.732	.720	—1.64	.730	.720	—1.36
	P. R. R.	.134	.017	.62	.740	.754	1.90	.729	.720	—1.23	.717	.713	—0.56

Heat.		Analyses at point O of A Rail Si.	P.	Mn.	CARBON DETERMINATIONS. A Rail O.	M.	% Seg.	B Rail O.	M.	% Seg.	C Rail O.	M.	% Seg.
92,149	C	.149	.017	.59	.668	.725	8.51	.698	.666	—4.48	.668	.660	—1.20
	P. R. R.	.160	.016	.59	.702	.744	5.98	.698	.660	—5.44	.685	.656	—4.24
92,172	C	.098	.018	.71	.660	.665	0.76	.672	.664	—1.18	.666	.684	2.70
	P. R. R.	.086	.017	.71	.658	.667	1.37	.667	.665	—0.30	.680	.689	1.32
92,192	C	.162	.018	.73	.743	.734	—1.22	.746	.720	—3.48	.740	.700	—1.35
	P. R. R.	.153	.020	.74	.749	.744	—0.66	.742	.748	0.81	.754	.749	0.66
92,223	C	.148	.020	.77	.770	.825	7.13	.770	.780	1.30	.774	.780	0.79
	P. R. R.	.134	.022	.78	.780	.832	6.65	.780	.787	0.90	.776	.780	0.51
92,363	C	.102	.017	.71	.704	.709	0.71	.690	.712	3.18	.700	.680	—2.86
	P. R. R.	.102	.014	.69	.705	.733	3.98	.678	.707	4.28	.691	.660	—4.49
92,448	C	.117	.017	.69	.637	.665	2.84	.646	.650	0.62	.632	.617	—2.37
	P. R. R.	.132	.016	.68	.651	.669	2.78	.653	.638	—2.23	.642	.636	—0.93
92,502	C	.166	.034	.85	.675	.722	6.95	.706	.690	—2.27	.694	.670	—3.46
	P. R. R.	.166	.032	.82	.700	.738	5.41	.692	.683	—1.30	.705	.661	—6.24
92,524	C	.150	.039	.86	.705	.755	7.10	.720	.730	1.40	.720	.710	—1.39
	P. R. R.	.168	.040	.86	.720	.771	7.08	.726	.760	4.69	.733	.708	—3.68
92,549	C	.159	.015	.74	.725	.748	3.18	.760	.740	—2.10	.768	.680	—8.11
	P. R. R.	.156	.013	.77	.722	.749	3.73	.761	.758	—2.76	.689	.689	—9.10
92,587	C	.128	.018	.65	.705	.763	8.21	.682	.712	4.39	.694	.710	2.30
	P. R. R.	.138	.015	.63	.708	.792	11.85	.707	.731	3.39	.693	.682	—1.59
92,639	C	.168	.020	.74	.733	.741	2.18	.710	.720	1.42	.720	.712	—1.11
	P. R. R.	.153	.018	.79	.745	.740	—0.67	.720	.736	2.23	.738	.713	—3.38
92,659	C	.086	.017	.66	.655	.698	6.58	.640	.670	4.69	.634	.670	5.68
	P. R. R.	.083	.019	.64	.663	.725	9.37	.665	.660	—0.75	.647	.641	—0.92
92,690	C	.195	.017	.77	.724	.726	0.30	.714	.700	—1.96	.714	.704	—1.40
	P. R. R.	.190	.020	.76	.732	.760	3.81	.714	.717	0.41	.709	.718	1.28
92,715	C	.100	.022	.70	.692	.740	6.94	.700	.720	2.86	.690	.700	1.47
	P. R. R.	.117	.020	.69	.714	.760	7.69	.718	.738	2.78	.671	.772	7.61
92,747	C	.120	.037	.68	.707	.735	3.96	.704	.710	0.85	.714	.700	—1.96
	P. R. R.	.116	.036	.71	.716	.732	3.23	.700	.738	5.42	.701	.690	—1.58
92,775	C	.150	.029	.82	.717	.765	6.69	.752	.778	3.46	.714	.702	—1.68
	P. R. R.	.141	.032	.86	.733	.770	5.04	.747	.767	2.69	.734	.701	—4.49
92,810	C	.144	.019	.63	.702	.742	5.69	.684	.720	3.75	.676	.670	—0.89
	P. R. R.	.136	.016	.65	.707	.789	5.92	.698	.742	6.29	.702	.684	—2.56
92,830	C	.121	.031	.74	.660	.702	6.37	.680	.700	2.91	.686	.670	—2.33
	P. R. R.	.116	.029	.75	.687	.709	3.22	.680	.716	5.30	.696	.691	—0.72
92,881	C	.079	.017	.75	.665	.660	—0.75	.650	.646	—0.62	.650	.640	—1.54
	P. R. R.	.078	.016	.72	.651	.676	3.80	.645	.651	0.92	.656	.664	1.22
92,911	C	.182	.021	.75	.748	.787	5.22	.730	.796	9.06	.740	.730	—1.34
	P. R. R.	.179	.023	.77	.756	.800	5.83	.738	.791	8.14	.764	.744	—2.61
92,926	C	.125	.018	.67	.699	.740	5.88	.702	.710	1.14	.700	.670	—4.29
	P. R. R.	.117	.015	.63	.685	.756	10.38	.715	.716	0.15	.715	.621	—6.16
92,978	C	.215	.026	.78	.710	.727	3.72	.710	.720	1.41	.720	.700	—2.77
	P. R. R.	.216	.027	.73	.727	.751	3.30	.716	.733	2.38	.718	.720	0.29
92,996	C	.100	.025	.71	.650	.666	2.48	.646	.640	—0.93	.632	.590	—6.64
	P. R. R.	.105	.027	.74	.668	.685	2.55	.650	.656	0.92	.641	.610	—4.83
93,010	C	.209	.018	.71	.632	.746	18.04	.676	.700	3.56	.684	.650	—4.96
	P. R. R.	.189	.018	.75	.651	.762	17.04	.685	.724	5.70	.684	.669	—2.18
93,029	C	.246	.033	.79	.708	.760	7.34	.730	.730	0	.720	.760	5.55
	P. R. R.	.226	.033	.79	.713	.764	7.16	.740	.740	0	.738	.760	2.98
93,078	C	.151	.022	.70	.669	.667	—0.30	.668	.660	—0.20	.678	.660	—2.65
	P. R. R.	.148	.026	.71	.662	.660	—0.30	.689	.651	—5.52	.694	.674	—2.88
93,096	C	.119	.030	.61	.683	.715	4.69	.680	.710	4.40	.670	.660	—1.49
	P. R. R.	.098	.030	.61	.705	.723	2.56	.691	.705	2.03	.692	.684	—1.16
93,122	C	.148	.024	.70	.746	.748	0.28	.740	.756	2.18	.744	.716	—3.76
	P. R. R.	.155	.024	.66	.745	.738	—0.94	.731	.745	1.92	.716	.694	—3.07
93,159	C	.095	.024	.81	.713	.689	—3.36	.728	.702	—3.56	.716	.680	—5.03
	P. R. R.	.107	.023	.77	.727	.696	—4.26	.702	.698	—0.56	.713	.682	—4.35
93,176	C	.122	.020	.65	.600	.657	9.50	.600	.630	5.00	.596	.614	3.02
	P. R. R.	.105	.022	.65	.614	.650	5.86	.612	.627	2.47	.616	.610	—0.97
93,214	C	.125	.022	.62	.665	.681	2.40	.674	.690	2.38	.660	.680	3.02
	P. R. R.	.117	.022	.62	.694	.689	—0.72	.664	.692	4.21	.669	.680	1.64
93,246	C	.142	.029	.71	.655	.674	2.91	.680	.680	0	.670	.680	1.49
	P. R. R.	.136	.029	.68	.669	.685	2.39	.683	.690	1.03	.690	.685	—0.72
93,280	C	.164	.027	.73	.735	.797	8.44	.716	.740	3.06	.714	.710	—0.56
	P. R. R.	.144	.022	.76	.753	.800	6.24	.749	.752	0.40	.754	.749	—0.66
93,302	C	.203	.028	.77	.690	.693	0.44	.680	.680	0	.680	.684	—0.59
	P. R. R.	.179	.027	.80	.714	.709	—0.70	.701	.707	0.87	.689	.685	—0.58
93,339	C	.128	.026	.75	.696	.767	10.37	.728	.756	3.86	.718	.680	—5.30
	P. R. R.	.120	.024	.79	.716	.789	10.20	.742	.760	2.42	.740	.682	—7.84
93,361	C	.142	.020	.70	.666	.720	8.12	.680	.670	—1.46	.654	.622	—4.89
	P. R. R.	.136	.018	.72	.680	.751	10.45	.700	.676	—3.42	.684	.634	—7.30
93,438	C	.183	.023	.68	.689	.662	—3.92	.676	.632	—6.52	.680	.630	—7.35
	P. R. R.	.179	.022	.67	.682	.683	—0.58	.680	.644	—5.33	.687	.656	—4.51
93,451	C	.141	.018	.61	.706	.650	—7.94	.690	.680	—1.45	.690	.630	—6.99
	P. R. R.	.130	.015	.59	.703	.652	—7.26	.707	.705	—0.28	.689	.644	—6.53
93,467	C	.134	.031	.83	.735	.748	1.78	.740	.750	1.35	.740	.750	1.35
	P. R. R.	.133	.029	.84	.750	.765	1.02	.743	.770	3.61	.756	.752	—0.53

Appendix B

RESULTS OF TESTS OF HADFIELD AND MARYLAND SPECIAL RAILS REMOVED FROM THE EASTBOUND TRACK OF THE LOW GRADE LINE, PHILADELPHIA DIVISION

These Hadfield and Maryland Special No. 2 rails were removed from track in 1920 after some five years' service, four test pieces of Hadfield and two pieces of Maryland Special rails being sent to the company's laboratory for examination.

	No. 2 Hadfield Rails				No. 2 Maryland Special Rails	
	8-B	30-B	4-C	12-D	13-C	11-F
Carbon O, per cent (see p. 22).	.647	.641	.637	.690	.636	.620
Carbon M, per cent (see p. 22)	.650	.627	.638	.668	.605	.523
Segregation, per cent.....	0.46	—2.18	0.16	—3.19	—4.87	—15.65
Brinell hardness, average...	251	242	263	266	253	248
Wear, A end, per cent.....	18.6	28.6	19.3	14.4	14.4	10.3
Wear, B end, per cent.....	20.5	26.9	20.3	17.6	11.0	15.6
Wear, Middle, per cent	22.0	31.8	19.3	20.3	14.9	17.8
Wear, Average, per cent...	20.4	29.1	19.6	17.4	13.4	14.6

The average carbon content of the Hadfield rails at point O was .654 per cent and of the Maryland Special rails .628 per cent. Carbon segregation in Hadfield rails was very slight, while in one of the Maryland rails the negative segregation was 15.65 per cent.

The average Brinell hardness of Hadfield rails was 255.5 and of Maryland rails 250.5.

Average wear: Hadfield 21.65 per cent, Maryland 14 per cent. Deep etching tests did not indicate the presence of cracks or shattering in any of the rails.

Appendix C

STEEL RAILS FROM SINK-HEAD AND ORDINARY RAIL INGOTS

By George K. Burgess

I. GENERAL PLAN OF INVESTIGATION

The results of the experimental rolling into rails of several types of ingots, including several designs of sink-head ingots and others, with the co-operation of the Maryland Steel Co., reported by Hadfield and Burgess,[1] looked sufficiently promising to the rail committee of the Pennsylvania Railroad to warrant the purchase of 100 tons of ingots cast by Sir Robert Hadfield in England, in order to make a more effective study of the suitability of this type of sink-head ingot for the manufacture of rails. It was also considered desirable to carry out similar series of tests of ingots of ordinary rail steel rolled at the same time and under as nearly identical conditions as possible in the same mill.[2] President F. W. Wood, of the Maryland Steel Co., Sparrows Point, Md., offered the facilities of that plant for this investigation, as in the case of previous experiments reported by Hadfield and Burgess. The rolling of ingots for the present investigation was done in 1915 at the Sparrows Point plant. The reduction of the results has been greatly delayed, but it is thought the subject-matter is still of sufficient interest to warrant publication.

The planning of the details of the investigation, after correspondence with Sir Robert Hadfield, was made by A. W. Gibbs, Chief Mechanical Engineer of Pennsylvania Railroad Co.; F. W. Wood, President of Maryland Steel Co.; and Dr. G. K. Burgess, Chief, Division of Metallurgy, Bureau of Standards; and the tests were carried out by members of the technical staffs of their respective organizations, to whom acknowledgment is here made for their indispensable aid.

It was expected by Sir Robert Hadfield that the sink-head ingots made under this system would yield rails of remarkably high quality as regards "soundness, freedom from all piping and all segregation." From an inspection of the data concerning the manufacture of the ingots made by this process he also felt confident in stating: "This shows in a remarkable manner the uniformity of the ingots; also that every one of them is perfectly sound, free from blowholes, with no piping, and segregation below 8 per cent discard."

The results of the present investigation of 37 ingots of the Hadfield type show that he was not far astray in the confident prediction of uniformity, physical soundness, and freedom from chemical segregation. In fact, it is difficult to imagine 37 ingots, from as many heats of steel, more uniform in quality and properties and as free from those undesirable qualities and uncertainties that beset the ordinary ingot from which rails were made.

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[1] Hadfield and Burgess, Sound Steel Ingots and Rails, Trans. Am. Inst. Min. Engrs., 51, pp. 862-880, 1915; J. Iron and Steel Inst., 91, pp. 40-124, 1915.

[2] See also the valuable paper comparing American-made sink-head and ordinary ingots for rails by Edward F. Kennedy: The Commercial Production of Sound and Homogeneous Steel, Am. Iron and Steel Inst., p. 144, 1915.

The ingots with which they were compared, the product of three heats, 5 from each heat, or 15 ingots in all, are not less instructive, in that each group, or heat, represents a distinct practice in open-hearth manufacture. In this investigation, therefore, from the point of view of steel making, we are really comparing the products rolled from 2 types of ingots representing 4 methods of manufacture.

The rolling, inspection, tests, and analyses were carried out with the greatest care, and by a series of actual weighings all the material from the several ingots was accounted for.

II. DETAILED SCHEME OF PROCEDURE

The detailed scheme of observations of rolling and tests of sink-heads and comparison ingots follows:

1. Ingots

Methods of Numbering Ingots.—The sink-head ingots were numbered H1, H2, etc. . . . H37, and the ingots made in the ordinary manner were numbered M1, M2, etc., . . . M15.

Weight of Ingots.—The sink-head ingots were weighed cold and the others were weighed hot. The approximate weight of the sink-head ingots was 5300 pounds each and of the comparison ingots 7300 pounds.

Size and Shape of Ingots.—The English-made ingots were cast with sink head on large end, while the American-made ingots were cast small end up; dimensions of both types of ingots are shown in Table 1, and details concerning the sink heads of Hadfield ingots are to be found in Table 2.

Composition of Ingots.—Each sink-head ingot was from a separate heat, the compositions of which, furnished by the manufacturer, are given in Table 2. The American-cast ingots were from three heats, and their chemical compositions are shown in Table 3.

Temperature of Ingots.—The temperature of pouring of the comparison ingots is shown in Table 6; the temperature of the sink-head ingots was taken when they were introduced into the soaking pits, the temperatures of which were also noted then and at intervals until the ingots were withdrawn from the soaking pits; the temperature of English (Table 7) and comparison (Table 8) ingots were also taken at the blooming mill. In Table 9 are shown typical ingot-rolling temperatures of both types of ingot.

Inspection of Ingots.—The sink-head ingots were inspected cold for surface defects, cracks, etc, and at the blooming mill during rolling for the existence and location of cracks, scrap, etc. (Table 4.) The other ingots were similarly inspected at the blooming mills (Table 5).

Disposition of Ingots.—Of the 37 sink-head ingots cast at Sheffield, 35 were rolled into blooms at the Sparrows Point mill, and the remaining 2 ingots were sectioned longitudinally for metallographic examination. The examination of H32 was made by the Bureau of Standards and that of H37 by Hadfields (Ltd.). In addition to splitting 2 ingots, it was also decided to examine similarly top blooms from one of each of the two types of ingot, H5 and M10. The blooms and ingots examined in this manner were selected at random. All blooms were rolled into rails directly without reheating, and all material was accounted for by actual weighing, as shown in Tables 10 and 11.

TABLE 1.—Dimensions of Ingots of Both Types

Part measured	Sink-head ingot	Comparison ingot
	Inches	Inches
Top	19½ by 19½	18¼ by 18¼
Bottom	17¼ by 17¼	19¼ by 19¼
Height	[a] 50½	63

[a] The height given is exclusive of the height of sink head, which was approximately 13¾ inches.

TABLE 2.—Results of Chemical Analyses and Head Particulars of Sink-Head Ingots [a]

Ingot number	Heat number	Chemical composition (percentages)					Sink-head particulars			
		C	Si	S	P	Mn	Height to which filled in head	Depth of settling	Capacity of cavity	Percentage of settling to total bulk of ingot
							Inches	Inches	Cm³	
H1	4774	0.65	.....	0.040	.....	0.94	14.00	8.25	9950	3.19
H2	4738	0.63–.64	.....	.042	.....	.91	13.50	9.00	10300	3.31
H3	4847	.63–.64	.....	.047	.....	.93	13.75	9.25	10450	3.37
H4	4915	.65–.66	.....	.049	.....	.92	14.00	9.75	9675	3.10
H5	4873	.69	.....	.050	.....	.95	14.00	9.38	10250	3.29
H6	4939	.63–.64	0.16	.045	0.028	.92	13.00	7.50	8800	2.84
H7	4627	.64	.....	.052	.....	.97	14.00	8.25	9600	3.08
H8	4680	.65	.14	.049	.029	.92	13.75	8.50	10250	3.29
H9	4709	.58	.....	.049	.....	.93	13.00	7.75	8930	2.88
H10	5085	.63–.64	.16	.042	.031	.86	13.25	9.25	11000	3.52
H11	5018	.64	.16	.039	.031	.92	14.00	8.75	10040	3.21
H12	4641	.67–.69	.....	.045	.....	.92–.94	14.50	8.50	9000	2.89
H13	5059	.63–.64	.....	.049	.....	.92	14.00	8.88	10750	3.44
H14	4835	.69	.....	.046	.....	.91	13.50	7.75	9520	3.05
H15	4978	.67–.68	.....	.051	.....	.96	14.50	9.88	9260	2.95
H16	4992	.66	.....	.045	.....	.94	13.50	9.75	9000	2.88
H17	4825	.66	.....	.045	.....	.92	13.50	6.88	9000	2.89
H18	4829	.66	.....	.041	.....	.98	14.00	8.50	11100	3.55
H19	5073	.63–.64	.....	.045	.....	.90	14.00	9.50	10500	3.37
H20	4696	.66	.....	.038	.....	.96	13.50	6.50	8600	2.77
H21	4801	.66	.....	.036	.....	.95	13.50	8.13	9150	2.90
H22	4723	.63	.....	.044	.....	.95	13.50	8.00	9900	3.17
H23	5046	.62–.63	.....	.042	.....	.93	13.50	7.00	10500	3.37
H24	5030	.60	.....	.056	.....	.94	13.50	10.13	11950	3.82
H25	4668	.58	.....	.042	.....	.93	14.50	8.50	10100	3.24
H26	4813	.64	.14	.048	.032	.93	14.00	8.63	10800	3.45
H27	4615	.64	.20	.048	.....	1.01	14.25	7.00	9000	2.89
H28	4588	.64	.19	.047	.....	.97	13.00	7.25	8930	2.86
H29	4908	.64	.....	.041	.....	.84	14.00	8.75	9750	3.11
H30	4861	.61–.62	.21	.045	.031	.92	14.00	9.63	10900	3.49
H31	4600	.65	.15	.049	.....	.96	13.50	8.50	9825	3.16
H32	5004	.65	.....	.052	.....	.94	14.00	8.50	10175	3.27
H33	4761	.65	.....	.048	.....	.90	13.50	8.50	10800	3.47
H34	5099	.63–.64	.....	.039	.....	.86	11.00	8.88	10040	3.34
H35	4887	.63	.....	.050	.....	.89	14.00	9.00	10500	3.36
H36	4653	.61	.....	.053	.....	.85	13.50	7.75	9900	3.17

[a] Furnished by Sir Robert Hadfield.

TABLE 3.—Results of Chemical Analyses of Maryland Steel

Heat number	Ingot numbers	Elements determined (percentages)						
		C	Si	S	P	Mn	Cr	Ni
2 x 4497	M1 –M5, inc.	.608–0.630	0.148	0.067	0.010	0.710–0.720	0.270	0.760
1 x 3632	M6 –M10, inc.	.642–.654	.185	.092	.014	.650–.660	.290	.780
2 x 4510	M11–M15, inc.	.642–.650	.191	.097	.019	.760–.810	.270	.760

TABLE 4.—Results of Inspection of Sink-Head Ingots and Blooms

Ingot number	Results of inspection of cold ingots for cracks, scrap, etc.	Time of charging ingots into pits	Time of drawing ingots from pits	Interval in pits	Time consumed in rolling in blooming mill (Min. sec.)	Results of inspection during rolling in blooming mill
24	1 side—bad splash in pouring, 1 rough corner	4:35 p. m. to 4:40 p. m., Aug. 15, 1915.	11:56 a. m. to 12:25 p. m., Aug. 16, 1915.	19 hrs., 32 mins.	2 10	Very small piece of scrap on one corner.
28	1 side—bad splash in pouring bottom half, 1 rough corner				2 22	Very small piece of scrap on sides and corners.
2	1 side rough, 2 rough corners				2 25	1 crack 18 inches from top on side of ingot.
15	1 side very rough near top, 2 rough corners				2 15	2 small cracks on corners 2 feet from top of ingot.
1	Sides good, 2 rough corners				2 10	Spot of scrap 2 feet from top.
21	1 rough side, 1 rough corner				2 20	Spot of scrap 2 feet from top. Small crack on corner 2 feet from top.
9	3 rough sides, 1 rough corner	4:45 p. m. to 4:52 p. m., Aug. 15, 1915.	12:29 p. m. to 12:46 p. m., Aug. 16, 1915.	19 hrs., 49 mins.	2 25	Cracked all around ingot at bottom of sink-head.
7	Sides O. K., 2 rough corners				2 15	Small spot of scrap 8 inches from top on corners.
35	3 sides—rough spots 1 foot from bottom, 1 rough corner				2 35	Small spots of scrap all over ingot.
13	3 rough sides, 2 rough corners				2 20	Small spots of scrap 12 inches from bottom.
22	1 side—bad splash in pouring, 1 rough corner				2 10	Small spots of scrap on corners 2 feet from bottom.
14	2 sides—splashed in pouring, 3 rough corners				2 20	Clean bloom.
19	1 side—bad splash in pouring, 2 rough corners	4:30 p. m. to 4:38 p. m., Aug. 16, 1915.	1:49 p. m. to 2:05 p. m., Aug. 17, 1915.	21 hrs., 22 mins.	1 30	Small spot of scrap on corner 1 foot from top.
26	1 side rough 1 inch from top, 2 rough corners				2 15	Small spots of scrap 2 feet from top.
18	1 side—bad splash in pouring, corners good				2 15	Cracked at bottom of sink-head.
6	2 sides—bad splash in pouring, 2 rough corners				2 20	1 small spot of scrap 4 feet from top and one 1 foot from bottom on sides.
23	2 sides—bad splash in pouring, 1 rough corner				2 25	
31	1 side—bad splash in pouring near bottom, 2 rough corners				2 30	1 spot of scrap 1 foot from top on side. Clean bloom. Clean bloom.
29	1 side—crack in mold 10 inches from top, 2 rough corners.	4:50 p. m. to 5:05 p. m., Aug. 16, 1915.	2:06 p. m. to 2:22 p. m., Aug. 17, 1915.	21 hrs., 15 mins.	2 40	Spots of scrap on corners and sides 18 feet from top.
	2 sides—rough spots in center				.. ..	
36	2 sides—rough spots 1 foot from bottom, corners good				2 20	Small spot of scrap 2 feet from top.
4	4 sides—splash in pouring, 2 rough corners				2 15	Spots of scrap at center across the corners.
11	2 sides—splash in pouring, 2 rough corners				2 20	Small spots of scrap all over the top third of ingot.
12	1 side—splash in pouring, corners good				2 25	Small spots of scrap 2 feet from top on corners and sides.
10	Sides good, 3 rough corners				2 30	Small spots of scrap 3 feet from bottom on corners.
16	2 sides—rough 2 feet from bottom, 1 rough corner	4:30 p. m. to 4:45 p. m., Aug. 17, 1915.	9:51 a. m. to 10:10 a. m., Aug. 18, 1915.	17 hrs., 22 mins.	2 20	Small spot of scrap 1 foot from top on corner.
20	2 sides rough, 3 rough corners				2 15	Clean bloom. Cracked at bottom of sink-head.
33	3 sides—bad splash in pouring 1 foot from top, 1 rough corner				2 20	Small spot of scrap at center on sides.
17	1 side—splash in pouring, 2 rough corners				2 20	Large spots of scrap on all sides.
30	3 sides—splash in pouring at center, 2 rough corners				2 15	Small spots of scrap 2 feet from top on sides.
27	1 side—splash in pouring 2 feet from bottom, 1 rough corner				2 30	Small spots of scrap on all sides. Cracked at bottom of sink-head.
8	1 side—splash in pouring 6 inches from bottom, 1 rough corner.	4:45 p. m. to 5:00 p. m., Aug. 17, 1915.	10:14 a. m. to 10:27 a. m., Aug. 18, 1915.	17 hrs., 28 mins.	2 25	Large spot of scrap at center of ingot on one side.
3	2 rough sides, 2 rough corners				2 40	Small spot of scrap 2 feet from top.
25	3 sides—splash in pouring, 1 rough corner				2 20	Large spot of scrap 2 feet from top on corner.
34	1 side rough at center, 2 rough corners				2 50	Large spots of scrap on all sides.
5	1 side—splash in pouring, corners good				2 25	Small spots of scrap on sides.
32	1 side—splash in pouring, 2 rough corners				.. ..	Not rolled.

TABLE 5.—Time Consumed in Rolling and Results of Inspection of Comparison Ingots and Blooms

Ingot number	Date rolled	Heat number	Time in molds	Time in soaking pits	Time consumed in rolling in blooming mill	Results of inspection during rolling in blooming mill
			Min.	H. M.	M. S.	
1	Aug. 16, 1915	2x4497	20	2 10	2 25	1 corner and 1 side cracked 1 foot from bottom.
2	do	2x4497	20	2 14	1 50	Small spot of scrap 2 feet from top on corner.
3	do	2x4497	20	2 18	2 35	Clear bloom.
4	do	2x4497	20	2 21	2 ..	Do.
5	do	2x4497	20	2 23	2 ..	Do.
6	Aug. 18, 1915	1x3632	23	1 40	1 50	Two small side cracks 4 feet from bottom.
7	do	1x3632	23	1 40	1 45	Clear bloom.
8	do	1x3632	23	1 41	2 10	Do.
9	do	1x3632	23	1 43	1 55	Do.
10	do	1x3632	23	1 45	2 10	1 small side crack 5 feet from bottom.
11	do	2x4510	30	2 15	2 ..	Clear bloom.
12	do	2x4510	30	2 15	2 ..	Small side crack 3 feet from top.
13	do	2x4510	30	2 17	2 ..	Clear bloom.
14	do	2x4510	30	2 19	2 10	Small side crack 3 feet from top.
15	do	2x4510	30	2 20	2 5	Small side crack 2 feet from bottom.

TABLE 6.—Pouring Temperatures of Comparison Ingots [a]

Observation number	Temperature for heat 1x3632	Temperature for heat 2x4510	Observation number	Temperature for heat 1x3632	Temperature for heat 2x4510
	°C	°C		°C	°C
1	.....	1557	16	1543	1522
2	.....	1545	17	1533	1512
3	[b] 1596	[c] 1545	18	1533	1507
4	[b] 1587	[c] 1538	19	1539	1497
5	[b] 1564	[c] 1540	20	1523	.....
6	[b]	[c] 1528	21	1539	.....
7	[b] 1578	[c] 1531	22	1537	.....
8	1559	1532	23	1537	.....
9	1557	1537	24	1529	.....
10	1557	.....			
11	1549	1527			
12	1557	1531			
13	1547	1521			
14	1551	1533			
15	1539	1527			

[a] Pouring temperatures group M_1–M_5, inclusive, not taken.
[b] Ingots from group M_6–M_{10}, inclusive. (Average pouring temperature, 1581°C.)
[c] Ingots from M_{11}–M_{15}, inclusive. (Average pouring temperature, 1536°C.)

TABLE 7.—Temperatures of Working of Sink-Head Ingots

Ingot number	Temperature of soaking pits		Ingot temperature		Rail temperature at finishing pass (taken on base of rail)	
	At time of charging ingots	After 14½ hours	When drawn	Blooming mill	First rail bar	Second rail bar
	°C	°C	°C	°C	°C	°C
1	700	1310	1300	1130	1016	1007
2	700	1310	1300	1140	1030	1020
15	700	1310	1300	1137	1026	1017
21	700	1310	1300	1123	1025	1005
24	700	1310	1300	1172	1025	1010
28	700	1310	1300	1157	1019	1008
7	750	1300	1290	1125	1028	998
9	750	1300	1290	1149	1024	1016
13	750	1300	1290	1116	1034	1008
14	750	1300	1290	1143	1043	1019
22	750	1300	1290	1144	1032	1018
35	750	1300	1290	1140	1034	1011
6	650	1200	1295	1149	1048	1025
18	650	1200	1295	1166	1032	1023
19	650	1200	1295	1180	1069	1044
23	650	1200	1295	1154	1047	1026
26	650	1200	1295	1173	1047	1034
31	650	1200	1295	1146	1036	1016
4	650	1240	1280	1156	1040	1016
10	650	1240	1280	1147	1046	1022
11	650	1240	1280	1136	1029	1012
12	650	1240	1280	1142	1047	1029
29	650	1240	1280	1148	1034	1005
36	650	1240	1280	1136	1038	1016
16	600	1305	1515	1182	1018	955
17	600	1305	1515	1164	1036	1016
20	600	1305	1515	1179	1045	1023
27	600	1305	1515	1153	1040	1024
30	600	1305	1515	1157	1032	1020
33	600	1305	1515	1160	1029	1017
3	600	1300	1316	1156	1033	1023
5	600	1300	1316	1149	.....	.....
8	600	1300	1316	1151	1029	1023
25	600	1300	1316	1153	1035	1000
34	600	1300	1316	1140	1014	1004
Average	658	1276	1299	1150	1034	1014
Maximum	750	1310	1315	1182	1069	1044
Minimum	600	1200	1280	1116	1014	955

TABLE 8.—Temperatures of Working of Comparison Ingots

Ingot number	Ingot temperature in blooming mill	Rail temperature at finishing pass (taken on base of rail)	
		First rail bar	Second rail bar
	°C	°C	°C
1	1149	1026	1006
2	1173	1016	993
3	1164	1040	1025
4	1179	1053	1039
5	1177	1064	1027
6	.....	1031	1005
7	1167	1029	1018
8	1176	1030	1001
9	1159	1038	1009
10	1180	1038	.....
11	1162	1039	1003
12	1181	1046	1025
13	1161	1032	1018
14	1149	1025	1016
15	1149	1024	1018
Average	1166	1035	1001
Maximum	1181	1064	1039
Minimum	1149	1016	993

TABLE 9.—Typical Rolling Temperatures

Temperature of sink-head ingot number							Temperature of comparison ingot number					
7	13	14	19	28	30	34	2	5	7	10	13	15
°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
1136	1157	1152	1212	1181	1195	1165	1184	1173	1179	1206	1179	1168
1147	1114	1147	1212	1171	1179	1165	1171	1184	1179	1198	1171	1157
1144	1103	1136	1176	1152	1165	1157	1168	1176	1176	1177	1168	1136
1114	1109	1147	1176	1147	1147	1141	1184	1176	1160	1179	1157	1149
1123	1109	1141	1160	1147	1147	1131	1171	1179	1163	1173	1157	1147
1125	1128	1141	1165	1147	1139	1123	1165	1184	1157	1168	1147	1136
1112	1093	1139	1165	1147	1144	1120	1163	1179	1157	1163	1147	1144
1103	.....	.....	.....	.....	1141	1125	.....	1147	.....	.....	.....	.....
Average							Average					
1125	1116	1143	1180	1157	1157	1141	1173	1177	1167	1180	1161	1149

	°C		°C
Grand average	1145	Grand average	1168
Maximum	1212	Maximum	1206
Minimum	1093	Minimum	1136

TABLE 10.—Disposition of Material from Sink-Head Ingots

[Weight in pounds. Discard made only to physically sound steel. H_5 not included in this table as the top bloom for this ingot was sent to the Bureau of Standards]

Ingot number	Ingot weight	Bloom crops				Weight of the four test pieces each 6 inches long	Rail crops at hot saw		
		Top		Bottom			Middle		Bottom
		Weight	Per cent of ingot, average	Weight	Per cent of ingot, average		No. 1	No. 2	
ROLLED AUG. 16, 1915									
24	5300	185	3.5	297	5.6	86	77	60	259
28	5300	233	4.4	112	2.1	79	74	32	30
2	5300	155	2.9	113	2.1	79	66	30	21
15	5300	167	3.2	129	2.4	79	83	31	48
1	5300	190	3.4	123	2.3	77	59	38	30
21	5300	442	8.4	116	2.2	85	43	77	75
9	5300	294	5.5	131	2.5	79	46	75	89
7	5250	234	4.5	122	2.3	79	54	54	74
35	5300	280	5.3	161	3.0	77	46	48	50
13	5300	191	3.6	141	2.7	81	58	39	58
22	5250	437	8.3	123	2.3	81	47	45	54
14	5300	231	4.4	138	2.6	78	53	50	67
ROLLED AUG. 17, 1915									
19	5300	160	3.0	120	2.3	77	49	50	69
26	5300	160	3.0	130	2.5	75	47	53	70
18	5300	237	4.5	116	2.2	76	50	77	99
6	5300	324	6.1	127	2.4	77	44	56	69
23	5350	134	2.5	131	2.4	78	49	79	100
31	5300	234	4.4	109	2.1	74	54	28	49
29	5350	566	10.6	123	2.3	77	44	63	78
36	5300	342	6.5	142	2.7	76	50	47	71
4	5350	270	5.0	123	2.3	71	50	46	56
11	5300	325	6.1	136	2.7	73	73	39	61
12	5350	204	3.8	124	2.3	74	54	60	97
10	5250	320	6.1	130	2.5	78	46	57	61
ROLLED AUG. 18, 1915									
16	5350	199	3.7	154	2.9	74	37	56	79
20	5300	276	5.2	122	2.3	73	43	66	72
33	5300	228	4.3	148	2.8	75	49	78	93
17	5300	145	2.7	117	2.2	74	53	73	93
30	5300	247	4.7	112	2.1	74	45	79	117
27	5300	245	4.7	97	1.9	78	57	63	71
8	5300	142	2.7	119	2.3	78	53	75	86
3	5300	205	3.8	115	2.2	71	81	55	65
25	5300	160	3.0	151	2.8	77	64	57	72
34	5300	195	3.7	166	3.2	83	58	43	57
Total	179 700	8357	4.3	4519	2.5	2623	1856	1879	2540

TABLE 10—Disposition of Material from Sink-Head Ingots—Continued

ROLLED AUG. 16, 1915—Continued

Ingot number	Ingot weight	Weight of rails				Total weight rolled, including crops and test pieces	Loss	
		A	B	C	D		Weight	Per cent of ingot, average
24	5300	768	1111	1117	1122	5082	218	4.1
28	5300	1232	1112	1120	1121	5145	155	2.9
2	5300	1315	1119	1120	1123	5141	159	3.0
15	5300	1277	1115	1120	1123	5172	128	2.4
1	5300	1284	1116	1122	1123	5162	138	2.6
21	5300	941	1121	1121	1124	5145	155	2.9
9	5300	1096	1121	1117	1119	5167	133	2.5
7	5250	1203	1116	1119	1122	5177	73	1.4
35	5300	1172	1113	1115	1118	5180	120	2.3
13	5300	1289	1116	1118	1120	5211	89	1.7
22	5250	1032	1116	1117	1122	5174	76	1.4
14	5300	1228	1113	1115	1117	5190	110	2.1

ROLLED AUG. 17, 1915—Continued

19	5300	1175	1108	1112	1115	5035	265	5.0
26	5300	1226	1108	1110	1112	5091	209	3.9
18	5300	1130	1107	1111	1115	5118	182	3.4
6	5300	1035	1107	1111	1111	5061	239	4.5
23	5350	1183	1102	1105	1109	5070	280	5.2
31	5300	1191	1100	1110	1117	5066	234	4.4
29	5350	867	1107	1111	1111	5147	203	3.8
36	5300	1082	1106	1106	1113	5135	165	3.1
4	5350	1228	1106	1107	1111	5168	182	3.4
11	5300	1161	1107	1116	1114	5205	95	1.8
12	5350	1194	1101	1107	1114	5129	221	4.1
10	5250	1077	1110	1114	1115	5108	142	2.7

ROLLED AUG. 18, 1915—Continued

16	5350	1191	1111	1111	1115	5127	223	4.2
20	5300	1175	1107	1111	1113	5158	142	2.7
33	5300	1153	1107	1112	1112	5155	145	2.7
17	5300	1269	1107	1113	1115	5159	141	2.7
30	5300	1151	1111	1112	1113	5161	139	2.6
27	5300	1229	1119	1120	1121	5200	100	1.9
8	5300	1274	1117	1109	1112	5165	135	2.5
3	5300	1204	1103	1106	1109	5114	186	3.5
25	5300	1275	1104	1109	1112	5181	119	2.2
34	5300	1157	1105	1115	1113	5092	208	3.9
Total	179 700	39 464	37 749	37 859	37 946	174 791	5519	3.0

TABLE 10.—Disposition of Material from Sink-Head Ingots—Continued

ROLLED AUG. 16, 1915—Continued

Ingot number	Ingot weight	Discard in rail on account of—			Material discarded to physically sound steel		Material available for rails			Ingot rolled with no draft on
		Sink head	Pipe	Total	Weight	Per cent of original ingot, average	Weight	Per cent of original ingot, average	Net per cent of ingot, average	Pass number
24	5300	161	.....	161	346	6.5	4043	76.3	87.8	1
28	5300	163	.....	163	396	7.5	4501	84.9	89.2	1
2	5300	230	.....	230	385	7.3	4526	85.4	88.9	1
15	5300	310	.....	310	477	9.0	4404	83.1	88.1	2
1	5300	292	.....	292	482	9.1	4430	83.5	87.8	2
21	5300	162	.....	162	604	11.1	4230	79.8	84.8	2
9	5300	.....	.....	.....	294	5.5	4532	85.5	91.8	1
7	5250	235	.....	235	469	8.9	4404	83.9	88.2	1
35	5300	160	.....	160	440	8.3	4435	83.7	88.6	1
13	5300	80	.....	80	271	5.1	4644	87.6	92.7	2
22	5250	.....	.....	.....	437	8.3	4468	85.1	88.8	2
14	5300	284	.....	284	515	9.7	4367	82.4	97.5	2

ROLLED AUG. 17, 1915—Continued

19	5300	326	.....	326	486	9.2	4261	80.4	85.0	1
26	5300	233	.....	233	393	7.4	4398	83.0	87.9	1
18	5300	.....	324	324	561	10.5	4215	79.5	85.0	1
6	5300	158	.....	158	482	9.1	4283	80.8	85.5	2
23	5350	291	.....	291	425	7.9	4286	80.1	86.7	2
31	5300	237	.....	237	471	8.9	4355	82.2	86.0	2
29	5350	64	.....	64	630	11.8	4209	78.7	84.3	1
36	5300	73	.....	73	415	7.8	4410	83.2	88.4	1
4	5350	87	162	249	519	9.7	4374	81.8	87.0	1
11	5300	254	.....	254	579	10.9	4317	81.5	86.4	2
12	5350	367	.....	367	571	10.7	4223	78.9	85.1	2
10	5250	148	.....	148	468	8.9	4346	82.8	86.8	2

ROLLED AUG. 18, 1915—Continued

16	5350	305	.....	305	504	9.4	4297	80.4	86.4	1
20	5300	313	.....	313	589	11.1	4266	80.5	85.4	1
33	5300	281	.....	281	509	9.6	4278	80.7	86.7	1
17	5300	342	.....	342	487	9.1	4336	81.8	87.4	2
30	5300	270	.....	270	517	9.8	4291	80.9	86.8	2
27	5300	233	.....	233	478	9.0	4434	83.7	88.5	2
8	5300	346	.....	346	488	9.1	4344	82.0	87.5	1
3	5300	378	.....	378	583	11.0	4215	79.5	84.6	1
25	5300	340	.....	340	500	9.4	4337	81.8	87.5	1
34	5300	389	.....	389	584	11.0	4184	78.9	84.1	2
Total	179 700	7512	486	7998	16 355	9.1	147 643	81.9	87.9	.....

TABLE 11.—Disposition of Material from Comparison Ingots

[Weights in pounds. Discard made only to physically sound steel]

HEAT NO. 2x4497

Ingot number	Ingot weight	Bloom crops				Weight of the five test pieces, each 6 inches long
		Top		Bottom		
		Weight	Per cent of ingot, average	Weight	Per cent of ingot, average	
1	7360	183	2.4	276	3.7	90
2	7030	243	3.4	209	2.9	98
3	7040	185	2.6	143	2.0	100
4	7130	189	2.6	226	3.1	95
5	7190	223	3.1	175	2.4	101
	35 750	.....	.....	.....	.....	.....

HEAT NO. 1x3632

6	7340	189	2.5	291	3.9	93
7	7200	205	2.8	215	2.9	90
8	7260	188	2.5	215	2.9	90
9	7240	225	3.1	252	3.4	93
	29 040	.....	.....	.....	.....	.....

HEAT NO. 2x4510

11	7510	664	8.8	236	3.1	96
12	7340	288	3.9	254	3.4	89
13	7190	490	6.8	175	2.4	88
14	7320	379	5.1	210	2.8	95
15	7480	236	3.1	235	3.1	96
	36 840	.....	.....	.....	.....	.....
Total	101 630	3887	3.8	3112	3.0	1314

HEAT NO. 1x3632

10	.....	3315	.....	230	.....	97

HEAT NO. 2x4497—Continued

Ingot number	Ingot weight	Rail crops at hot saw			Weight of rails					
		Middle		Bottom	X	A	B	C	D	E
		No. 1	No. 2							
1	7360	48	58	71	930	1117	1117	1117	1123	1126
2	7030	84	96	94	517	1114	1115	1117	1120	1122
3	7040	95	92	74	675	1110	1109	1115	1117	1119
4	7130	147	81	37	660	1108	1108	1115	1116	1120
5	7190	89	100	59	774	1108	1109	1113	1115	1119
	35 750	.....	.....	.....	.....	.....	.....	.....	.....	.....

HEAT NO. 1x3632—Continued

6	7340	44	63	75	878	1118	1118	1121	1121	1123
7	7200	34	56	28	880	1116	1114	1117	1122	1122
8	7260	60	59	73	888	1111	1112	1122	1120	1120
9	7240	23	59	94	783	1118	1118	1122	1123	1125
	29 040	.....	.....	.....	.....	.....	.....	.....	.....	.....

HEAT NO. 2x4510—Continued

11	7510	36	87	145	591	1102	1106	1111	1110	1116
12	7340	48	76	115	826	1105	1103	1106	1108	1111
13	7190	42	29	123	625	1101	1101	1104	1104	1106
14	7320	37	80	127	775	1099	1099	1104	1101	1103
15	7480	69	70	123	1011	1103	1106	1107	1109	1108
	36 840	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	101 630	856	1006	1238	10 813	15 530	15 535	15 591	15 609	15 640

HEAT NO. 1x3632—Continued

10	.....	.....	68	140	.....	.....	.....	1115	1116	1117

TABLE 11.—Disposition of Material from Comparison Ingots—Continued

HEAT NO. 2x4497—Continued

Ingot number	Ingot weight	Total weight rolled, including crops and test pieces	Discard in rail on account of pipe.	Material discarded to physically sound steel		Material available for rails			Date rolled
				Weight	Per cent of original ingot, average	Weight	Per cent of original ingot, average	Per cent of net ingot, average	
1	7360	7256	505	688	9.3	6115	83.1	88.5	Aug. 16, 1915
2	7030	6929	.....	243	3.4	6203	88.2	94.8	Do.
3	7040	6934	.....	185	2.6	6345	90.1	95.8	Do.
4	7130	7002	336	525	7.4	5986	83.9	90.2	Do.
5	7190	7085	.....	223	3.1	6439	89.5	95.0	Do.
	35 750	.....	.....	1864	5.2	31 088	86.9	92.8	

HEAT NO. 1x3632—Continued

6	7340	7234	505	694	8.2	6067	82.6	88.3	Aug. 18, 1915
7	7200	7099	505	710	9.8	6056	84.1	88.2	Do.
8	7260	7158	163	351	4.8	6400	88.1	93.5	Do.
9	7240	7135	336	561	7.7	6146	84.8	90.4	Do.
	29 040	.....	.....	2316	8.0	24 669	85.0	90.2	

HEAT NO. 2x4510—Continued

11	7510	7400	1515	2179	29.0	4717	62.8	07.4	Aug. 19, 1915
12	7340	7229	336	624	8.5	6112	83.2	89.2	Do.
13	7190	7088	2356	2846	39.5	3873	53.8	56.7	Do.
14	7320	7209	1682	2061	28.2	4694	64.1	68.3	Do.
15	7480	7373	1815	2051	27.4	4825	64.5	69.1	Do.
	36 840	.....	.....	9761	26.5	24 221	65.8	70.2	
Total	101 630	100 131	10 054	13 941	13.7	79 978	78.7	83.8	

HEAT NO. 1x3632—Continued

10	.....	7180	.....	.....	.....	.....	.....	.....	Aug. 18, 1915

Blooming Mill.—All ingots were rolled in 13 passes in a two-high mill to blooms 8 by 8½ inches. The English made ingots entered the blooming mill with the sink head toward the rolls. One half received the first, or "squaring up," pass in this direction, no draft being given on second pass; the other half were given no draft on the first pass, "the squaring up" being done on pass No. 2 (Table 10). The comparison ingots were rolled according to ordinary practice, entering the rolls the small end first.

2. Blooms

Each ingot was cut into 8 blooms (8 by 8⅛ inches) as shown in Fig. 1 and 2, rolled directly into rails, that is, without reheating of blooms. The second bloom from sink-head ingots made 2 rails (C and D), and that from the comparison ingots made 3 rails (C, D, and E). "The first

bloom from the sink-head type of ingot made a B and, generally, a short A rail; the first bloom from the comparison type of ingot made a B, A, and (short) X rail. The blooms were sheared top and bottom as little as possible for the safe passage of the bar through the rolls. Each piece cut was marked, weighed, and preserved.

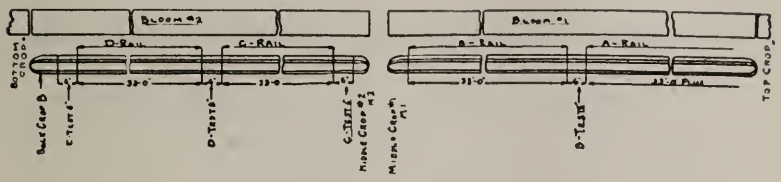


FIG. 1.—*Method of cutting blooms and rails from sink-head ingots*

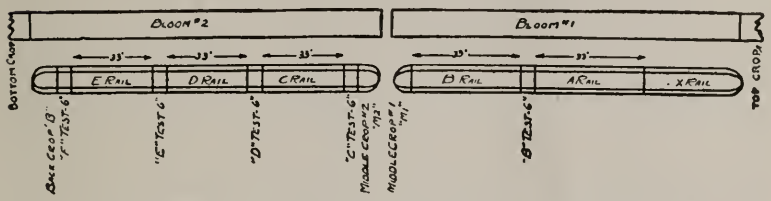


FIG. 2.—*Method of cutting blooms and rails from comparison ingots*

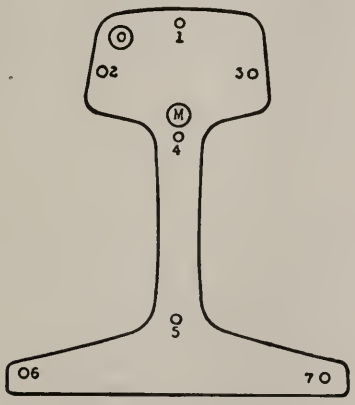


FIG. 3.—*Section of 100-pound P. S. rail, showing location of various* tests

Drillings for chemical analysis were taken at "O" and "M." Hardness determinations were made at the other positions indicated

3. Rails

In the rail mill there are 6 passes in the roughing rolls, 4 in the intermediate rolls, and 1 finishing pass, making a total of 24 passes from ingot to finished rail. The rails, which were Pennsylvania 100-pound section (Fig. 3), were cut at the hot saw as shown in Figs. 1 and 2.

The temperature of all rails was taken at the finishing pass. The rails were inspected for surface defects, piping, and discard to physically sound steel. The classification into "firsts" and "seconds" from surface conditions were made by the Pennsylvania Railroad Co. inspectors (Table 12); the discard to "physically sound steel" was made by cutting back in 5-foot lengths.

TABLE 12.—Classification of Rails Rolled from Sink-Head and Comparison Ingots [a]

Rails from sink-head ingots				Rails from comparison ingots			
Ingot number	B rail	C rail	D rail	B rail	C rail	D rail	E rail
1	1	2	1	1	1	1	2
2	1	1	1	1	1	1	1
3	1	2	1	1	1	1	1
4	2	2	2	1	1	1	1
5	([a])	2	2	1	1	1	2
6	2	2	2	1	1	1	1
7	2	2	2	1	1	1	1
8	2	2	2	1	1	1	1
9	1	1	2	1	1	1	1
10	2	1	2	([b])	1	1	1
11	2	2	2	1	1	1	2
12	2	1	2	1	1	1	1
13	2	2	2	([b])	2	1	1
14	1	1	1	([b])	1	1	1
15	2	2	2	1	1	1	1
16	2	2	2				
17	1	1	2				
18	1	1	1				
19	1	1	1				
20	2	2	2				
21	1	2	1				
22	1	1	1				
23	1	1	2				
24	1	1	1				
25	2	2	2				
26	1	1	1				
27	2	2	2				
28	2	2	2				
29	1	2	1				
30	2	2	2				
31	1	2	1				
32	2	2	2				
33	1	2	2				
34	2	2	2				
35	1	1	1				

		Per ct.
No. 1 rails	43	41
No. 2 rails	61	59
Total	104	100

		Per ct.
No. 1 rails	53	93
No. 2 rails	4	7
Total	57	100

[a] Inspection made by Pennsylvania Railroad Co. inspectors.
[b] Sent to Bureau of Standards.

The HA, the MX, and MA rails were held for tests to be described later. All pieces of rail were stamped to identify the ends.

4. Tests

Mechanical Tests.—The first sound 5-foot length obtained was taken as the drop-test piece. The test was made in the usual way by dropping a 2000-pound tup from a height of 18 feet upon the head of the rail which

was supported at 2 points 3 feet apart. This test gives record of permanent set, elongation of the base, and the number of blows required for the destruction of the rail.

The 6-inch test pieces (B, C, D, etc., Fig. 1 and 2), the drop-test pieces, and the specimens from the MA position were examined for ultimate tensile strength, yield point, elongation (2-inch gage length), reduction of area, and hardness by Brinell and scleroscope. All specimens for the tension tests were cut longitudinally.

Metallographic Tests.—There were taken of each test-piece section, a sulphur print, a light etching, and two photomicrographs at 100 diameters. Photomicrograph A was taken at upper part of web, B corresponds approximately with O position (Fig. 8 to 12, inclusive). These tests were also made on sections of the 5-foot pieces of the MX, MA, and HA rails to accompany the determinations of discard for chemical segregation.

Chemical Tests.—Determinations were made of the amounts of carbon, sulphur, phosphorus, manganese, and silicon at the "O" and "M" positions (Fig. 3) for test pieces (B, C, D, etc.) of all the rails; samples from the 5-foot pieces of MX, MA and HA were also analyzed. Some specifications contain a clause which provides for the rejection of rails when the M position shows a carbon content more than 12 per cent greater (positive segregation) or more than 12 per cent less (negative segregation) than the O position. In the present investigation, all material showing more than 12 per cent positive or negative carbon segregation was considered as unavailable for rails. The railroad using this specification has found from experience that 12 per cent is the maximum safe limit of segregation.

III. DESCRIPTION OF OPERATIONS AND DISCUSSION OF RESULTS

1. Ingot Practice

Since the sink-head ingots were cast in England and rolled in this country, they were necessarily subjected to the unusual process, at least in rail manufacture as ordinarily practiced, of reheating from the cold condition. The plan was considered of allowing at least some of the comparison ingots to go "stone cold" and reheat them before rolling. However, in view of the fact that the ordinary type of ingot is not designed to meet this condition, which practically never obtains in practice and which, therefore, would be a possible misleading condition to impose on the comparison ingots and of no practical value, the comparison ingots were all rolled directly after being cast. These ingots were stripped from 20 to 30 minutes after casting and put into the soaking pits while still hot, where they remained from 1 hour and 40 minutes to 2 hours and 23 minutes.

The sink-head ingots after preliminary heating were charged into relatively cool pits (for temperature details see Section III, 2, Temperature Observations). The heat was gradually turned on after ½ hour and the ingots remained in the pits from 17⅓ hours to 21⅓ hours. The 35 sink-head ingots which were rolled were divided into three series and rolled on suc-

cessive days, August 16, 17, 18, 1915. Three heats of comparison ingots were rolled, 1 on August 16 and 2 on August 18. There was no delay or other unusual conditions in the mill during the rolling. The ingots of a group were rolled in succession, without intermission, and after the mill had been warmed up by rolling at least one complete heat of the regular product of the mill.

2. Temperature Observations

Temperature observations were taken of the soaking pits before, and at intervals, after immersion of ingots of both types; of all ingots in the blooming mill; and of rails from both series of ingots at the finishing pass. In order to heat them gradually, the Hadfield ingots lay on the surface of the soaking pits approximately 12 hours before charging. They were too hot to bear the hand comfortably when charged, at which time their estimated temperature was about 50° C. (122° Fahr.). The pits which received these sink-head ingots were allowed to cool to the temperature of 600° C. (1112° Fahr.)—750° C. (1382° Fahr.) (Table 7). The immersion of the ingots further cooled the pits by some 200° C. (392° Fahr.) as measured immediately after charging. The gas was turned on the pits one-half hour after charging. The comparison ingots were charged into the soaking pits hot, according to the usual practice.

Table 7 shows the values of the pit temperatures (1) before charging, (2) about 14½ hours after charging, and (3) just before drawing the sink-head ingots. These temperatures were taken with a platinum-rhodium termocouple connected to a pivot type of indicator. The couple was inclosed in nickel sheath except the tip, which was exposed. In some cases the temperatures were obtained by the use of an optical pyrometer of the Morse type.

By means of the optical pyrometer temperatures of the ingots were taken during the rolling. Average values obtained from 7 or 8 observations with optical pyrometer at alternate passes, after the first roughing pass, were taken of the ingots in the blooming mill. The temperature of the steel at the surface was lowered about 17° C. (63° Fahr.) to 40° C. (104° Fahr.) during the rolling into blooms. Typical illustrations of rolling temperatures are given in Table 9 for several ingots of both types. Table 7 contains finishing temperatures of Hadfield rail bars taken at the finishing pass by sighting on the center of base of rail bar with an optical pyrometer. Each observation is the average of two readings.

In Table 8 are similar data for the comparison ingots and rails, except that the pit temperatures were not taken. It will be noted that good uniformity of rolling and finishing temperatures was obtained.

A series of measurements was taken to compare the temperatures of this investigation taken at the finishing pass with those taken[3] at the hot saw by sighting on the head of the rail. The reading noted in Tables 7 and 8 of finishing temperatures should be reduced by about 11° C. (52° Fahr.) to correspond to previous observations at hot saw.

[3] B. S. Tech. Papers, No. 38, Observations on finishing temperatures and properties of rails.

The observed ingot and rail temperatures were taken on the outside oxidized surfaces, which are colder than the interior metal by 75° C. (167° Fahr.) to 100° C. (212° Fahr.) This would account for the apparent discrepancy between the soaking-pit and ingot temperatures, and would make the average true finishing temperature somewhat higher than 1100° C. (2012° Fahr.)

3. General Comparison of the Two Types of Ingot

(a) Size of Ingots.—The sink-head ingots were of 5200 pounds weight and the comparison ingots of 7300 pounds. In computing the percentage of ingot material available for rails the necessary constant valued deductions—i. e., the bottom-bloom crops and the middle and bottom rail crops—work to the relative disadvantage of the ingot of lesser weight. It was on this account that in Tables 10 and 11 the percentage of material available for rails is based upon both the original weight of ingot less the weight of the bottom-bloom crops and the initial weight minus the middle and bottom rail crops.

(b) Loss in Heating.—The sink-head ingots were weighed while cold before reheating, and the comparison ingots were weighed while hot. The abnormal loss in weight sustained by the former should be deducted from the nominal ingot weight in computing the net ingot. It so happens that the average bottom-bloom crop for the ingot made in an ordinary manner is 0.5 per cent greater than for the sink-head ingot; so that if the loss on heating for the comparison ingots is taken as 0.5 per cent there will be an exact balance. The English-cast ingots remained in the soaking pits some 10 times as long as the comparison ingots. If it is nevertheless preferred to compare actual percentages of material available for rails, that from the sink-head ingots should be increased by 2.5 per cent because there was a loss of 3 per cent, of which some 2.5 per cent can be charged to reheating. When this correction is made it is seen that the average sink-head ingot gives about 84.8 per cent material available for rails instead of 81.9 per cent. Ingot H24 should not be used in the discussion, as it was accidentally given an excessive bloom crop. The expression "material available for rails," as used here and in Tables 10 and 11, refers to only physically sound steel. Subsequent chemical analyses showed a much greater discard was necessary to eliminate segregation above 12 per cent (Tables 17 and 18).

(c) Comparison by Heats.—It will be noted that the three heats of comparison ingots have each very distinct characteristics; for example, as expressed in material available for rails, which are the results of varying open-hearth and casting practice. In group M1-M5 the percentage of material available for rails was 86.9 per cent; in group M6-M9, 85 per cent; and in group M11-M15, 65.8 per cent (Table 11). It was for this reason that, in addition to the general average of properties of all Maryland rails, averages were computed for each of the three Maryland heats. The three rollings of the Hadfield ingots show great uniformity, however expressed, and thus indicate that the manufacture of the ingots in all cases apparently was carried out in accordance with a uniform practice.

TABLE 13.—Mechanical and Chemical Characteristics of Rails from Sink-Head Ingots

Rail No.	Average, ADFM,[a] or DFAR[b]	Tension tests				Hardness		Elements determined (per cent)										
		Yield point	Ultimate strength	Elongation, per cent in 2 inches	Reduction of area	Brinell	Scleroscope	Carbon			Manganese		Phosphorus		Silicon		Sulphur	
								O	M	Segregation[c]	O	M	O	M	O	M	O	M
		Lbs. in.	Lbs. in.		Per cent													
HA	Average	62 074	125 986	14.5	23.48	259	33	0.652	0.733	+12.73	0.88	0.85	0.035	0.033	0.137	0.139	0.047	0.050
	ADFM[a]	1 585	2 342	0.7	1.25	6	1	.018	.044	7.84	.04	.03	.003	.002	.008	.007	.003	.005
	DFAR[b]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HB	Average	63 212	126 381	13.3	23.89	264	31	.649	.664	2.32	.89	.89	.032	.032	.139	.139	.047	.048
	ADFM	1 206	2 027	0.9	1.50	8	1	.016	.018	1.35	.03	.04	.002	.002	.011	.012	.004	.005
	DFAR	+1 138	+395	−1.2	+0.41	+5	−2	−.003	−.069	−10.41	+.01	+.04	−.003	−.001	+.002	0	0	−.002
HC	Average	62 941	126 054	13.6	24.30	260	31	.653	.644	− 1.27	.89	.88	.032	.031	.139	.138	.047	.046
	ADFM	1 109	2 130	0.7	1.18	9	1	.017	.017	1.68	.03	.04	.002	.002	.011	.012	.003	.003
	DFAR	867	+68	−0.9	+0.82	+1	−2	+.001	−.089	−14.00	+.01	+.03	−.003	−.002	+.002	−.001	0	−.004
HD	Average	63 029	126 158	13.6	24.47	260	30	.650	.621	4.48	.89	.88	.032	.031	.139	.137	.047	.044
	ADFM	1 310	2 381	0.7	1.14	7	1	.017	.022	1.81	.03	.03	.002	.002	.011	.012	.004	.004
	DFAR	+955	+172	−0.9	+0.99	+1	−3	−.002	−.112	−17.21	+.01	+.01	−.003	−.002	+.002	−.002	0	−.006
HE	Average	62 264	124 303	14.2	25.70	256	30	.637	.639	+ 0.40	.89	.88	.032	.037	.137	.137	.046	.046
	ADFM	1 418	2 900	0.6	1.63	10	1	.019	.023	1.42	.03	.04	.002	.003	.011	.011	.004	.004
	DFAR	+190	−1 683	−0.3	+2.22	−3	−3	.015	.094	12.33	+.01	+.03	−.003	−.001	0	−.002	−.001	−.004
GENERAL AVERAGES																		
H	General averages	62 704	125 771	13.8	24.38	260	31	0.648	0.660	1.94	0.89	0.88	0.032	0.033	0.138	0.138	0.047	0.047
	ADFM	1 326	2 356	0.8	1.34	8	1	.017	.025	2.75	.03	.04	.002	.002	.010	.011	.004	.005

[a] Average deviation from mean.
[b] Deviation from A rail.
[c] Shows percentage carbon variation of M from O position.

(d) Inspection of Ingots.—The sink-head ingots were examined while cold for surface defects, and the surface condition of all ingots was noted by another observer as they passed through the blooming mill (Tables 4 and 5). There were side splashes, rough sides, and rough corners on nearly all the sink-head ingots, and only 4 of the 35 were noted as clean blooms in rolling, as compared with 8 clean blooms from the 15 comparison ingots.

(e) Comparison of Chemical Composition.—(1) *Sink-Head Ingots* (Table 13).—The chemical composition of the rails from the sink-head ingots show a remarkable degree of uniformity. Thus for the O analysis the average carbon is 0.648 per cent, with an average deviation from mean of 0.017. If we take the C test piece as representing the ingot composition, the average for carbon of C-M is 0.644 per cent and C-O .0653 per cent, the average deviation from mean in each case being 0.017.

The average phosphorus content of the O position is 0.032 per cent, with an average deviation of 0.002; for sulphur (O position) the average is 0.047 per cent, with a deviation of 0.004. For the M position the concordance is somewhat less good. Manganese and silicon are very uniformly distributed.

(2) *Comparison Ingots* (Table 14).—These ingots were cast with small end uppermost, and, except for a nickel content of 0.75 per cent and chromium content of 0.28 per cent, were of a composition and uniformity comparable with the sink-head type, the average O position having a carbon content of 0.645 per cent (sink head 0.648 per cent), with an average deviation from mean of 0.036. The manganese content is 0.70 per cent, as compared with 0.89 per cent for the sink-head ingots; the phosphorus content is 0.019 per cent, while in the sink-head ingot it is 0.047 per cent. Group M11-M15 has an average phosphorus content of 0.028 per cent, which quite closely agrees with that of English-cast ingots. This subgroup is also from its method of manufacture the best to compare with the imported ingots.

The sulphur content of the comparison ingots follows the grouping by heats; the O analysis of C rail, for example, for M1-M5 has a sulphur content of 0.076 per cent; for M6-M10 the sulphur is 0.101 per cent; for M11-M15 the sulphur is 0.118 per cent. The manganese and silicon of the first two groups are practically identical, while both are slightly higher in the third group (M11-M15). The chromium and nickel content are practically constant at 0.28 per cent for the former and 0.75 per cent for the latter for all three groups.

4. The Sink-Head Ingots, Their Manufacture and Classification

There were 37 ingots of this Hadfield type cast large end up and each provided with a sink head (Table 1 and Fig. 4). The ingots were fed by the Hadfield method in the usual manner, with charcoal and blast continued for about 20 to 40 minutes until the molten steel had set on the top of the head.

The steel was made by the converter process, a small furnace being used, and each ingot represents a heat. These ingots are of remarkable

TABLE 14.—Mechanical and Chemical Characteristics of Rails from Comparison Ingots

Rail No.	Average, ADFM[a] or DFAR[b]	Tension tests				Hardness		Carbon		
		Yield point	Ultimate strength	Elongation, per cent in 2 inches	Reduction of area	Brinell	Sclero-scope	O	M	Seg.[c]
		Lbs./in.²	Lbs./in.²		Per cent					
M1-5A	Average	60 721	120 960	13.5	23.16	246	32	0.601	0.736	+22.32
	ADFM[a]	821	2 928	1.0	3.23	5	1	.023	.056	6.65
M6-9A	Average	60 115	123 600	12.8	21.42	252	33	.652	.730	+11.88
	ADFM	885	1 075	1.0	1.61	8	0	.009	.045	6.04
M11-15A	Average	64 963	129 695	13.3	23.43	267	34	.682	.738	+ 8.52
	ADFM	1 322	1 226	0.2	1.50	7	1	.150	.058	9.60
M1-5B	Average	64 145	127 910	11.6	20.80	260	33	.641	.709	+10.60
	ADFM	1 048	2 048	0.5	1.61	3	1	.011	.041	4.78
M6-9B	Average	63 140	128 188	11.6	20.18	259	33	.675	.715	+ 6.18
	ADFM	238	938	0.6	1.20	6	1	.008	.095	1.51
M11-15B	Average	64 484	130 140	12.5	23.92	263	33	.661	.671	− 1.53
	ADFM	345	888	0.4	0.70	1	1	.070	.190	1.49
M1-5C	Average	61 752	124 290	12.5	24.18	244	32	.634	.613	− 3.40
	ADFM	411	548	0.4	0.57	7	1	.007	.030	4.09
M6-10C	Average	61 982	127 520	12.0	20.81	255	34	.673	.673	0.00
	ADFM	593	556	0.6	0.56	2	1	.011	.021	2.12
M11-15C	Average	62 415	126 850	13.1	26.77	354	32	.673	.646	− 4.02
	ADFM	704	1 720	0.5	0.71	3	1	.070	.050	0.89
M1-5D	Average	61 254	123 295	13.1	26.70	245	32	.635	.596	− 6.12
	ADFM	1 207	1 016	0.7	1.40	5	1	.011	.016	1.04
M6-10D	Average	61 158	125 700	12.5	23.75	246	31	.671	.635	− 5.43
	ADFM	686	940	0.4	0.50	2	0	.003	.009	1.56
M11-15D	Average	62 290	126 750	13.6	26.95	252	31	.674	.607	− 9.88
	ADFM	772	1 060	0.3	0.26	4	1	.080	.070	1.58
M1-5E	Average	59 233	120 465	14.7	30.40	240	31	.623	.534	−14.35
	ADFM	1 150	722	0.6	1.30	3	0	.003	.010	1.32
M6-10E	Average	59 000	123 055	13.9	26.72	246	33	.650	.617	− 4.99
	ADFM	446	874	0.4	1.44	2	1	.008	.013	2.15
M11-15E	Average	60 944	124 050	14.3	29.26	242	31	.643	.570	−11.40
	ADFM	1 372	1 020	0.4	0.55	6	1	.110	.110	1.25

M1-5F	Average	67 592	117 190	15.5	32.34	234	32	.585	.595	+ 1.73
	ADFM	500	1 048	0.6	0.59	8	1	.004	.033	6.07
M6-10F	Average	59 395	121 735	15.2	30.03	244	32	.637	.643	− 0.53
	ADFM	382	1 248	0.5	0.73	5	2	.007	.008	2.05
M11-15F	Average	59 450	120 065	15.8	32.68	249	32	.613	.611	− 0.39
	ADFM	1 028	1 502	0.2	0.82	2	0	.040	.080	1.42
SUMMARY BY INGOT POSITION										
M-A rails	Average	62 063	124 834	13.2	22.76	255	33	644	0.735	+14.41
	ADFM	2 091	3 472	.6	2.14	11	1	.064	.045	7.53
	DFAR	0	0	0	0	0	0	0	0	0
M-B rails	Average	63 979	128 786	11.9	21.73	260	33	.665	.697	+ 5.00
	ADFM	840	1 488	.5	1.19	4	1	.032	.109	2.67
	DFAR	+ 1 916	+3 952	− 1.3	− 1.03	+ 5	0	+ .021	− .038	− 9.41
M-C rails	Average	62 050	126 220	13.5	23.92	251	33	.660	.644	− 2.42
	ADFM	631	1 606	.6	.61	6	1	.029	.034	2.35
	DFAR	− 13	+ 1 388	+ .3	+ 1.16	− 4	0	+ .016	− .091	−11.99
M-D rails	Average	61 567	125 248	13.1	25.80	248	31	.660	.612	− 7.14
	ADFM	999	1 495	.6	.72	4	1	.031	.032	1.39
	DFAR	− 496	+ 414	− .1	+ 3.04	− 7	− 2	+ .016	− .123	− 7.27
M-E rails	Average	59 726	122 523	14.3	28.79	243	32	.638	.573	−10.40
	ADFM	1 068	1 536	.5	1.09	5	1	.043	.044	1.57
	DFAR	− 2 337	− 2 311	+ 1.1	+ 6.03	− 12	− 1	− .006	− .162	− 4.01
M-F rails	Average	58 826	119 663	15.5	31.68	242	32	.611	.616	+ .27
	ADFM	1 052	2 049	.5	.71	8	1	.017	.040	3.18
	DFAR	− 3 237	− 5 179	+ 2.3	+ 8.92	−13	− 1	− .033	− .119	−14.14
SUMMARY BY HEATS										
M1-5	Average	60 783	122 352	13.5	26.26	245	32	0.620	0.631	+ 1.80
	ADFM	1 873	3 068	1.2	3.53	9	1	.020	.064	10.84
M6-10	Average	60 757	124 792	13.1	24.03	250	33	.636	.665	+ .98
	ADFM	1 416	2 151	1.2	3.13	6	1	.024	.038	5.64
M11-15	Average	62 431	126 258	13.8	27.17	255	32	.661	.641	− 3.22
	ADFM	1 604	4 681	.7	2.62	3	1	.038	.042	5.14
GENERAL AVERAGE										
	General average	61 368	124 545	13.6	25.78	250	32	0.645	0.646	+ 0.16
	ADFM	1 113	1 941	.6	1.01	6	1	.036	.051	3.12

[a] Average deviation from mean. [b] Deviation from A rail. [c] Shows percentage carbon variation of "M" from "O" position.

TABLE 14.—Mechanical and Chemical Characteristics of Rails from Comparison Ingots—Continued

Rail No.	Average, ADFM[a] or DFAR[b]	Manganese		Phosphorus		Silicon		Sulfur		Nickel		Chromium	
		O	M	O	M	O	M	O	M	O	M	O	M
M1-5A	Average	0.64	0.68	0.010	0.013	0.127	0.130	0.058	0.086	0.75	0.75	0.28	0.29
	ADFM[a]	.01	.02	.001	.001	.005	.006	.004	.015	.01	.01	.01	.01
M6-9A	Average	.66	.67	.015	.018	.142	.145	.096	.124	.72	.72	.29	.30
	ADFM	.01	.01	.000	.002	.007	.008	.007	.018	.00	.01	.00	.00
M11-15A	Average	.77	.79	.028	.032	.178	.179	.118	.117	.73	.73	.26	.27
	ADFM	.01	.02	.001	.004	.015	.018	.004	.029	.00	.01	.00	.00
M1-5B	Average	.68	.69	.012	.013	.129	.130	.074	.097	.77	.77	.28	.28
	ADFM	.01	.01	.000	.000	.007	.006	.004	.011	.01	.00	.00	.02
M6-9B	Average	.68	.68	.016	.018	.168	.147	.103	.115	.75	.75	.28	.28
	ADFM	.01	.01	.001	.001	.020	.002	.001	.006	.01	.01	.01	.01
M11-15B	Average	.78	.78	.030	.029	.174	.174	.122	.120	.73	.74	.27	.27
	ADFM	.01	.01	.001	.001	.007	.007	.001	.006	.00	.01	.01	.00
M1-5C	Average	67	.67	.013	.012	.128	.128	.076	.073	.77	.78	.27	.28
	ADFM	.01	.00	.001	.001	.007	.006	.001	.005	.00	.01	.01	.01
M6-10C	Average	.66	.66	.017	.017	.145	.145	.101	.103	.74	.74	.26	.29
	ADFM	.01	.01	.000	.001	.004	.003	.001	.002	.01	.01	.01	.01
M-11-15C	Average	.78	.78	.029	.027	.173	.172	.118	.114	.74	.74	.27	.27
	ADFM	.01	.02	.000	.001	.008	.008	.003	.002	.00	.00	.01	.00
M1-5D	Average	.67	.66	.012	.016	.127	.145	.007	.094	.78	.74	.29	.29
	ADFM	.01	.01	.001	.001	.008	.001	.003	.004	.00	.01	.01	.01
M6-10D	Average	.67	.67	.016	.012	.144	.127	.100	.069	.74	.78	.29	.28
	ADFM	.00	.00	.001	.001	.002	.008	.002	.003	.00	.01	.01	.01
M11-16D	Average	.78	.78	.028	.027	.173	.172	.119	.108	.74	.74	.27	.26
	ADFM	.01	.00	.001	.001	.009	.006	.002	.003	.00	.01	.01	.01
M1-5E	Average	.67	.67	.012	.011	.130	.130	.073	.060	.77	.77	.28	.28
	ADFM	.01	.01	.001	.000	.006	.006	.001	.001	.00	.00	.01	.01
M6-10E	Average	.66	.66	.016	.016	.148	.147	.097	.090	.74	.75	.29	.28
	ADFM	.01	.00	.001	.001	.001	.001	.003	.003	.01	.00	.01	.00
M11-15E	Average	.78	.78	.028	.024	.175	.176	.114	.096	.74	.73	.27	.26
	ADFM	.01	.01	.001	.001	.010	.007	.001	.002	.00	.00	.00	.01
M1-5F	Average	.67	.65	.010	.011	.132	.133	.065	.070	.77	.77	.28	.28
	ADFM	.01	.02	.000	.001	.006	.006	.001	.005	.01	.01	.01	.01

M6-10F	Average	.66	.68	.016	.018	.147	.151	.096	.097	.73	.74	.29	.28
	ADFM	.00	.03	.001	.003	.002	.006	.003	.003	.01	.01	.01	.01
M11-15F	Average	.78	.77	.026	.026	.177	.178	.104	.106	.74	.73	.26	.26
	ADFM	.02	.01	.002	.000	.007	.007	.002	.001	.00	.00	.00	.00

SUMMARY BY INGOT POSITION—Continued

M-A rails	Average	0.69	0.71	0.018	0.021	0.149	0.152	0.091	0.106	0.73	0.73	0.28	0.29
	ADFM	.01	.02	.001	.002	.009	.010	.005	.020	0	.01	.00	.00
	DFAR	.00	0	0	.000	0	0	0	0	0	0	0	0
M-B rails	Average	.71	.71	.020	.019	.156	.150	.099	.110	.75	.75	.28	.27
	ADFM	.01	.01	.001	.001	.010	.005	.002	.008	.01	.01	.01	.01
	DFAR	+ .02	0	+.002	+.002	+.007	−.002	+.008	+.004	+ .02	+ .02	.00	− .02
M-C rails	Average	.70	.70	.019	.019	.149	.148	.098	.096	.75	.75	.27	.28
	ADFM	.01	.01	.000	.001	.006	.006	.001	.002	.00	.01	.01	.01
	DFAR	+ .01	− .01	+.001	+.002	.000	−.004	+.007	−.010	+ .02	+ .02	− .01	− .01
M-D rails	Average	.71	.70	.019	.018	.148	.148	.099	.090	.75	.75	.28	.27
	ADFM	.01	.00	.001	.001	.006	.006	.002	.003	.00	.01	.01	.01
	DFAR	+ .02	− .01	+.001	−.003	−.001	−.004	+.008	−.016	+ .02	+ .02	0	− .02
M-E rails	Average	.70	.71	.019	.017	.150	.151	.095	.082	.75	.75	.28	.27
	ADFM	.01	.01	.001	.001	.005	.005	.002	.002	.00	.00	.01	.01
	DFAR	+ .01	.00	+.001	−.004	+.001	−.001	+.004	+.024	+ .02	+ .02	.00	− .02
M-F rails	Average	.70	.70	.017	.018	.152	.154	.088	.091	.74	.75	.28	.27
	ADFM	.01	.02	.001	.001	.005	.009	.002	.003	.01	.01	.01	.01
	DFAR	+ .01	− .01	−.001	−.003	+.003	+.002	−.003	−.015	+ .01	+ .02	.00	− .02

SUMMARY BY HEATS—Continued

M1-5	Average	0.67	0.67	0.012	0.012	0.129	0.130	0.071	0.076	0.77	0.77	0.28	0.28
	ADFM	.01	.01	.001	.001	.007	.007	.006	.012	.01	.01	.01	.01
M6-10	Average	.66	.65	.016	.017	.146	.147	.098	.103	.74	.74	.29	.29
	ADFM	.01	.02	.001	.001	.003	.004	.004	.010	.01	.02	.01	.01
M11-15	Average	.78	.78	.028	.027	.175	.175	.116	.114	.74	.74	.26	.27
	ADFM	.01	.01	.001	.001	.009	.009	.005	.002	.01	.01	.01	.01

GENERAL AVERAGE—Continued

	General average	0.70	0.71	0.019	0.019	0.151	0.151	0.095	0.096	0.75	0.75	0.28	0.28
	ADFM	.01	.001	.001	.001	.007	.007	.002	.006	.00	.01	.01	.01

[a] Average deviation from mean. [b] Deviation from A rail.

uniformity of chemical composition, weight, and sink-head characteristics (Table 2). About 30 to 40 seconds were required for pouring each ingot.

(a) Sink-Head Effect.—Due to the uncertainty of the location of the sink-head junction, an arbitrary allowance has to be made in advance at hot saw or shears or one risks having the A rails rejected. If the total top discard (bloom and rail) is adjusted to 13 per cent there will be no rails rejected on account of sink head; if this is set at 8 per cent one would expect

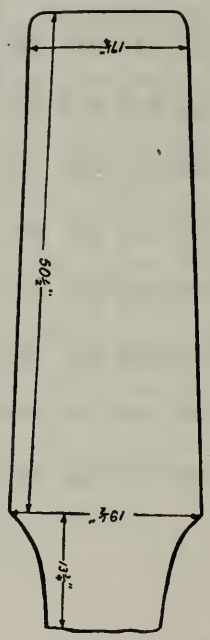


Fig. 4.—*Sink-Head Ingot*

about one-half the A rails to contain surface imperfections caused by the sink-head and ingot junction (Table 10). The sink-head alone entails on the average a discard of about 9.1 per cent of the Hadfield ingot.

The ingot usually enters the rolls with large end and sink head first; it appears, however, to make no difference which end of ingot is first subjected to the "squaring-up" pass. The presence of the sink-head appears to present no difficulties in either the blooming mill or rail mill. One ingot cracked at the bottom of the sink head during rolling, but this was without effect on the passage of this bloom through the rolls.

(b) Piping in Sink-Head Ingots.—Two of the 35 sink-head ingots were examined as rails had pipes, detected in the mill, extending into the ingot 10 or 11 per cent, or to some 5 per cent below the sink-head in some cases (Table 10). All piping would appear to be eliminated with a discard

of 11 per cent, which is very nearly that required to eliminate all sink-head imperfections and carbon segregation above 12 per cent.

(c) Influence of Surface Condition of Ingots on Rail Classification.—It was possible to make a very careful examination for flaws in the surfaces of the sink-head ingots while cold; their condition during rolling, as well as of the comparison ingots, was also noted. In this way some idea of the relation of "second" rails to ingot surface may be established (Tables 4, 5, and 12).

There were a relatively large number of "second" rails from the sink-head ingots, 61 out of a total of 104 rails, or 59 per cent. There were only 4 in 57 from the comparison ingots, or 7 per cent. The A rails were not included for either group. This inspection was made by Pennsylvania Railroad Co. inspectors.

There appears to be no reason why ingots of the sink-head type should not be as well surfaced as any other, and the high percentage of seconds should not be attributed to the type of ingot, as the bottom of the sink-head was well within the A rail, which was not classified. Probably the severe and unusual reheating conditions, together with the original surface as influenced by condition of the molds and teeming practice, contributed somewhat toward producing the large number of "seconds" from the sink-head ingots. A large percentage of "seconds" was similarly obtained from the reheated Hadfield ingots reported on by Hadfield and Burgess.[4]

5. The Comparison Ingots, Their Manufacture and Classification

There were 15 Maryland ingots, in 3 groups of 5 each, of about 7300 pounds each, top-poured into ingot molds with small end up. (See Table 1 for dimensions.) They were rolled as portions of three heats on different dates, the total number of ingots in a heat being 13 or 20. The time of teeming into molds was about 35 seconds each. The product from each heat thus forms a distinctive group and should be considered separately. The ingots were selected arbitrarily before being cast as the five to be poured in succession after the second one of the heat. The heats were three of a series of rail steel from the ordinary output of the open hearth and were not especially chosen.

The first 10 ingots, heats 2 × 4497 (M1-M5) and 1 × 3632 (M6-.10) were apparently made from rising steel, while ingots M11-M15 of heat 2 ×4510 were from quiet or "killed" steel; ingots M6-M15 were deoxidized with aluminum; ingots M1-M10 were chilled on top, M1-M5 with cast-iron caps and M6-M10 with water.

The effects of these differences in furnace and casting practice are very striking on the finished product. Thus the deoxidized flat-top ingots (M11-M15) show, as would be expected, pronounced piping; for this group the average discard to physically sound steel is 26.5 per cent and ranging from 8.5 to 39.5 per cent. With this discard may be compared the discard of 5.2 per cent for the first Maryland group and 8 per cent for the second, and except in 2 cases out of 35 a negligible discard for piping below the

[4] See footnote 1.

sink head of the Hadfield ingots. The small discard (6.6 per cent) to sound steel for the average of the first two Maryland groups is, however, misleading, as there may exist internal or inclosed pipes, especially for the second or deoxidized group. In the first comparison group (M1-M5) one would expect to find a spongy, segregated structure in the upper part of the ingot. This is brought out in some of the sulphur prints of rail from the upper part of the ingots of this group, a typical one being shown in Fig. 8.

Of the first group, M5 contains a very pronounced pipe near the bottom of the ingot in the F position (Fig. 9). The question may be raised as to whether the practice of chilling the ingot top does not tend to produce internal pipes which may be distributed anywhere along the center line of the ingot.

The phenomenon of segregation, which is intimately allied to the furnace and casting practice for the comparison ingot, is discussed separately. The mechanical properties, as brought out by the several tests—ultimate strength, yield point, elongation, reduction of area, hardness and drop test —show less dependence on the processes of manufacture.

6. Comparison of Chemical Segregation of Ingots of Both Types

Each comparison ingot furnished 6 and each sink-head ingot 4 rails. In comparing the segregation of the A test piece it should be remembered that for the sink-head ingots this position is that of the drop-test piece at about 9 per cent below the top (including sink-head), while the comparison ingots the A test piece is at the junction of the X and A rails, or at 10.6 per cent from the top of ingot. Therefore they are in sufficiently similar positions for comparison, except that 10.6 per cent of a comparison ingot 7260 pounds) represents 770 pounds of steel, or 23 feet of rail, while 9.6 per cent of a sink-head ingot (5300 pounds) represents 509 pounds, or only 15 feet of rail, or the A position in the comparison has a rail discard 8 feet greater than the sink-head ingot on the average.

The E position of the rails from sink-head ingots should be compared with the position of the comparison ingots F, the sink head D with comparison E, the sink head C with comparison C and D, and the sink head B with comparison B.

For both types of ingot the longitudinal segregation of carbon is very slight along the O positions, while for the M positions, or along the center line of the ingot, it is quite marked, the carbon being greatest at A near the top of the ingot, decreasing to the H-D (or M-E) position, and rising again as the bottom of the ingot is approached. The results given are for the three types of comparison ingot, but for this effect, the type of ingot appears to be less important than for other factors.

The segregation of the sink-head ingots and of the three groups of ingots made with small end uppermost are discussed separately with reference to influence and method of manufacture.

(a) Segregation in Sink-Head Ingots.—The sink-head ingots were of "piping" steel deoxidized with aluminum. Each represents a separate heat of converter steel.

These ingots were in general of remarkable uniformity as regards segregation (Table 15), thus showing the furnace and casting practice also to have been very uniform. At the A test piece, 9.1 per cent below the top of the ingot on the average, the segregation, though variable, is always positive; that is, the carbon content of the M position is greater than that of the O position. Fourteen of 35 ingots have a segregation greater than 12 per cent and 3 greater than 25 per cent; for one of these (H13), the A position is only 5.1 per cent below the top of the ingot (Table 10).

For these 35 sink-head ingots the discard for segregation above 12 per cent is located 13 per cent (plus or minus 1.86) below top of ingot, with a maximum of 17.5 per cent and a minimum of 5.1 per cent (Tables 10 and 17).

TABLE 15.—Percentage Carbon Segregation in Rails from Sink-Head Ingots

Ingot	Rail A	Rail B	Rail C	Rail D	Rail E	Ingot	Rail A	Rail B	Rail C	Rail D	Rail E
H1	13.02	−0.15	−3.75	−4.59	1.23	H21	11.91	1.66	−0.75	0.45	2.61
H2	9.44	.00	−2.67	−6.77	−1.60	H22	2.67	− .75	.31	−3.48	− .30
H3	11.65	−5.33	−3.89	−7.42	− .79	H23	24.35	.77	−1.69	−4.09	−1.42
H4	16.49	4.83	−3.82	−3.41	− .62	H24	21.94	−2.26	−2.83	−2.93	−4.55
H5	.....	.....	−1.29	−1.30	− .44	H25	5.17	2.68	1.52	−2.56	2.73
H6	9.25	4.86	−1.73	−6.40	2.78	H26	34.16	.60	−1.22	−7.11	.92
H7	19.79	.30	−1.95	− .15	− .60	H27	4.76	1.38	.00	−4.48	3.09
H8	3.34	1.68	− .15	−5.20	1.57	H28	26.77	2.97	−3.12	−5.43	.16
H9	23.77	4.87	−1.12	−6.20	− .34	H29	10.50	3.58	−1.72	−7.55	.49
H10	20.63	2.17	.31	−4.54	3.09	H30	15.57	2.54	− .47	−4.32	− .97
H11	4.69	3.74	.32	−5.16	.32	H31	12.89	2.95	.31	−3.70	.62
H12	2.16	1.44	−2.41	−6.52	− .57	H33	3.83	2.06	−7.41	−2.68	.60
H13	46.69	−3.11	−4.35	−1.27	−2.79	H34	10.11	6.75	−2.72	−5.16	−2.96
H14	2.48	1.49	.00	−4.32	.30	H35	10.33	3.32	−5.11	−6.16	1.46
H15	7.83	4.08	−4.63	1.18	1.63	H36	15.48	2.37	2.54	−4.59	− .96
H16	13.93	4.52	−2.33	−9.74	−1.41	Average	+12.73	+2.32	−1.27	−4.48	+0.40
H17	1.50	4.75	1.22	−5.33	3.29	ADFM[a]	7.48	1.35	1.68	1.81	1.42
H18	5.20	1.96	− .30	−3.46	2.14						
H19	9.66	2.85	.00	−7.28	.81						
H20	1.04	2.60	−1.96	−5.07	1.73						

[a] Average deviation from mean.

TABLE 16.—Percentages Carbon Segregation in Rails from Comparison Ingots

Ingot	Rail A	Rail B	Rail C	Rail D	Rail E	Rail F
M1	30.88	7.17	−8.80	− 5.07	−12.34	−13.45
M2	30.39	27.55	.31	− 7.73	−13.06	3.93
M3	13.30	9.63	.96	− 5.79	−15.20	4.44
M4	20.17	5.28	−8.23	− 4.41	−15.89	2.96
M5	16.85	3.37	−1.25	− 7.61	−15.24	10.75
M6	16.51	9.20	−4.98	− 5.93	− 3.71	.62
M7	19.34	5.07	3.68	− 3.44	− 8.79	.00
M8	2.51	5.05	.91	− 5.76	− 6.65	.64
M9	9.15	5.38	.73	− 8.27	− 1.42	− 5.91
M10	.....	.....	− .31	− 3.73	− 4.41	.....
M11	3.08	− .87	−4.95	− 8.69	−11.78	− 1.16
M12	32.52	−1.61	−3.61	−11.00	−11.68	− 2.08
M13	.....	−1.98	−5.31	− 7.12	−13.82	− 1.47
M14	4.74	−6.26	−2.48	−11.92	− 8.62	.16
M15	.15	3.07	−3.73	−10.66	−11.09	2.61
Average	+14.41	+5.00	−2.42	−7.14	−10.40	+ .27
ADFM[a]	7.53	2.67	2.35	1.39	1.57	3.18

[a] Average deviation from mean.

At A the average segregation is + 12.73 per cent, ± 7.48; at B the segregation is + 2.32, ± 1.35, with only 4 negative values; at C it is — 1.27 per cent, ± 1.66, with 10 positive values; at D it is 4.48 per cent, ± 1.81, with only 2 positive values; and at E only + 0.40 per cent, ± 1.42, with 15 negative values (Table 15).

(b) Segregation in Comparison Ingots.—(1) *Group M1-M5 (Heat 2 × 4497).*—This heat has no aluminum addition in molds, and cast-iron caps were put on the tops of the ingots as soon as poured. It was found that the ingot tops were rounded after the steel had solidified; therefore, they were made of rising steel not specially deoxidized in the mold. The ingots were stripped 20 minutes after casting and remained in soaking pits from 2 hours and 10 minutes to 2 hours and 23 minutes. This is about as rapid handling of ingots in the molds as it is possible to have, although the time in pits could have been lessened. The resulting composition and segregation is strikingly characteristic of their history.

TABLE 17.—Necessary Total Discard (Percentage) in Rails from Sink-Head Ingots [a]

[H24 was omitted, as this ingot was given an excessive bottom crop due to error in judgment at mill. *s*=discard for segregation. *p*=discard for physical unsoundness.]

Ingot number	Top	Bottom (*p*)	Middle (*p*)	Chemical	Physical	Total
H1	*s* 16.2	3.0	1.8	16.2	4.8	21.0
H2	*s* 12.3	2.5	1.8	12.3	4.3	16.6
H3	*s* 13.9	3.4	2.6	13.9	6.0	19.9
H4	*s* 17.5	3.4	1.8	17.5	5.2	22.7
H6	*s* 13.4	3.7	1.9	12.4	5.6	18.0
H7	*s* 14.0	3.7	2.1	14.0	5.8	19.8
H8	*s* 12.1	3.9	2.4	12.1	6.3	18.4
H9	*s* 15.0	4.2	2.3	15.0	6.5	21.5
H10	*s* 15.6	3.6	2.0	15.6	5.6	21.2
H11	*s* 14.3	3.7	2.1	14.3	5.8	20.1
H12	*p* 10.7	4.1	2.1	.....	16.9	16.9
H13	*s* 13.0	3.8	1.8	13.0	5.6	18.6
H14	*s* 13.8	3.8	1.9	13.8	5.7	19.5
H15	*s* 12.6	3.3	2.2	12.6	5.5	18.1
H16	*s* 12.4	4.4	1.7	12.4	6.1	18.5
H17	*p* 9.1	4.0	2.4	.....	15.5	15.5
H18	*s* 13.9	3.9	2.4	13.9	6.3	20.2
H19	*s* 11.8	3.6	1.9	11.8	5.5	17.3
H20	*s* 14.0	3.7	2.1	14.0	5.8	19.8
H21	*s* 14.6	3.6	2.3	14.6	5.9	20.5
H22	*s* 11.5	3.4	1.8	11.5	5.2	16.7
H23	*s* 10.6	4.3	2.4	10.6	6.7	17.3
H25	*p* 9.4	4.2	2.3	.....	15.9	15.9
H26	*s* 14.3	3.8	1.9	14.3	5.7	20.0
H27	*s* 9.7	3.2	2.5	9.7	5.7	15.4
H28	*s* 13.8	2.7	2.0	15.8	4.7	8.5
H29	*s* 16.8	3.8	2.0	16.8	5.8	22.6
H30	*p* 9.8	4.3	2.3	.....	16.4	16.4
H31	*p* 8.8	3.0	1.6	.....	13.5	13.5
H33	*s* 12.5	4.6	2.4	12.5	7.0	19.5
H34	*s* 14.4	4.2	1.9	14.4	6.1	20.5
H35	*s* 11.6	4.0	1.8	11.6	5.8	17.4
H36	*s* 15.9	3.9	1.9	15.9	5.8	21.7
Average	13.0	3.7	2.1	11.5	7.2	18.4
Deviation	1.86	.....	.....	.....	.....	.....

[a] The total discard (top, middle, and bottom) includes the discard necessary to eliminate piping and segregation above 12 per cent.

TABLE 18.—Necessary Total Discard (Percentage) in Rails from Comparison Ingots [a]

[*s*=discard for segregation. *p*=discard for physical unsoundness. B, E, D refer to rails having above 12 per cent segregation or having inclosed pipes.]

Ingot number	Top	Bottom	Middle	Chemical	Physical	Total
M1	*s* 31.9	*p* 4.7	*s* 32.0 E+D	63.9	4.7	68.6
M2	*s* 24.8	*p* 4.3	*s* 34.5 B+E+D	59.3	4.3	63.6
M3	*s* 23.9	*p* 3.1	*s* 34.4 E+D	58.3	3.1	61.4
M4	*s* 23.7	*p* 3.7	*s* 34.5 E+D	58.2	3.7	61.9
M5	*s* 28.6	*p* 3.3	*ps*33.7 E+D	62.3	3.3	66.6
Average	26.6	3.4	33.8	60.4	3.8	64.2
M6	*s* 25.3	*p* 5.0	*p* 1.5	25.3	6.5	31.8
M7	*s* 23.7	*p* 3.9	*p* 1.3	23.7	5.2	28.9
M8	*s* 23.3	*p* 4.0	*p* 1.6	23.3	5.6	28.9
M9	*s* 23.8	*p* 4.8	*p* 1.1	23.8	5.9	29.7
Average	24.0	4.44	1.4	24.0	5.8	29.8
M11	*p* 29.0	*p* 5.1	*p* 1.6	0	35.7	35.7
M12	*s* 19.8	*p* 5.0	*p* 1.7	19.8	6.7	26.5
M13	*p* 39.5	*p* 4.1	[b] *p* 1.0	0	44.6	44.6
M14	*p* 28.2	*p* 4.6	[b] *p* 1.6	0	34.4	34.4
M15	*p* 27.4	*p* 4.8	[b] *p* 1.9	0	34.1	34.1
Average	26.8	4.7	1.6	4.0	31.1	35.1
Average	26.0	3.8	13.0	30.0	14.1	43.9
Deviation	±3.3	.....	.....	.....	.....	.....

[a] The total discard (top, middle, and bottom) includes the discard necessary to eliminate piping and segregation above 12 per cent.
[b] M13 and M14 contain trace of piping in B position. M15 has a small pipe at F.

The top of the ingot is characterized by high and variable segregation; thus the total top discard required to eliminate segregation above 12 per cent ranged from 23.7 to 31.9 per cent for the five ingots, as compared with a top discard of 2.6 to 9.3 per cent to the physically sound steel; that is, free from pipe (Tables 11 and 18). Within this range of discard for segregation, however, the segregation in a single ingot varied by enormous amounts, such as 26.52 to 94.62 per cent for ingot M2 and —7.36 to 49.28 per cent for ingot M5 (Table 20). This type of ingot is also characterized in all cases, by high negative segregation in the lower portion of the ingot, particularly marked at the E position, where it ranges from —12.34 per cent to —15.89 per cent (Table 16). Except for M1, at the bottom of the ingot F position (—13.45 per cent, Table 16), there is a reversal to relatively small positive segregation. All but M2 contain a well-marked soft streak at F, the bottom of the ingot, and in the case of M5 this streak incloses a pronounced pipe (Fig. 9 and 10). The total material that should be discarded from this type of ingot for segregation ranges from 58.2 to 63.9 per cent (Table 18). Provision should be made for a larger bottom-bloom crop than is customary to eliminate both segregation and piping in the bottom of the ingot. The bottom rail and the adjacent one from every ingot of this group (M1-M5) should be discarded for segregation. The bottom rail has in addition elements of physical weakness shown by the soft steel streaks which may inclose pipes.

(2) *Group M6-M10 (Heat 1 × 3632).*—The ingots of this heat had rounded tops on which water was put a few moments after casting; they were also treated while being cast with 2 ounces of aluminum per ton of steel. They were, therefore, of rising steel deoxidized in the molds and should show somewhat greater tendency to piping than the first group; this is borne out by the results. The ingots of the second group required a discard averaging 8 per cent on account of pipe, while only one of the first group required a discard in excess of this amount (Table 11).

With respect to the B, C, D, E, and F positions for this group, the segregation is relatively low (max., 9.20 per cent, Table 16) and uniform from one ingot to another, as well as within any particular ingot downward from the B position. The top discard for carbon segregation greater than 12 per cent (in O and M positions) is 23.3 to 25.3 per cent (Table 18), and within this discard the segregation is less extreme than in ingots of the first group, the maximum being about 25 per cent, which obtained in only two positions out of 29 (Table 20).

(3) *Group M11-M15 (Heat 2 × 4510).*—Two ounces of aluminum per ton were added to the ingots M11-M15 for the purpose of deoxidation. The ingot tops, which were flat after pouring into molds, were not chilled with caps or water. These ingots were, therefore, of quiet, piping steel and apparently more nearly approach the type of steel represented by the sink-head ingots than do the other two groups of comparison ingots. They remained somewhat longer in the molds (30 minutes as compared with 20 and 23 minutes) before stripping, and slightly longer in the soaking pits than the other comparison ingots.

The considerable piping at the top of the ingots of this group is very strikingly characteristic of the above open-hearth and casting practice. The carbon segregation in the upper half and at the bottom of this type of ingot is slight, but there is developed negative segregation ranging about 11 per cent at the D and E positions (Table 16). In contrast to the other two types of Maryland ingot the extent of the top discard is determined (Table 18), except for M12, which shows other anomalies, by piping (average discard 26.8 per cent) rather than by segregation (average discard 16.4 per cent, Table 22). The metallographic examination shows a small pipe in rail M15 at the bottom of the ingot in the F position, and incipient piping in M13 and M14 at the B position.

TABLE 19.—Percentage Segregation of Carbon in the "A" Rails of Sink-Head Ingots[a]

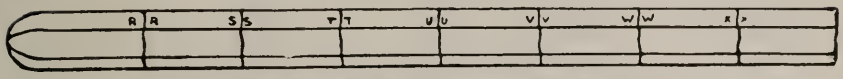


Diagram of cutting up of "A" rail of sink-head ingots

Ingot	Carbon	R	S	T	U	V	W	X
H1	Carbon O	0.632	0.649	0.647	0.650	0.658	0.648	0.647
	Carbon M	.902	.789	.732	.683	.673	.674	.673
	Segregation	42.72	21.57	13.14	/ 5.08	2.28	4.01	4.02
H2	Carbon O	.610	.636	.635	.632	.634	.637	.636
	Carbon M	.967	.804	.705	.690	.659	.653	.654
	Segregation	58.52	26.42	/ 11.02	9.18	3.94	2.51	2.83
H3	Carbon O	.657	.670	.667	.653	.657	.....	.....
	Carbon M	.746	.708	.674	.682	.673	.....	.....
	Segregation	13.55	/ 5.67	1.05	4.44	2.44	.....	.....
H4	Carbon O	.605	.657	.654	.655	.649	.656	664
	Carbon M	.719	.777	.767	.708	.719	.691	.674
	Segregation	18.84	18.26	17.28	/ 8.09	10.79	5.34	3.06
H6	Carbon O	.640	.641	.641	.643	.644	.....	.....
	Carbon M	.805	.697	.675	.676	.674	.....	.....
	Segregation	25.78	/ 8.74	5.30	5.13	4.66	.....	.....
H7	Carbon O	.630	.669	.647	.667	.663	.662	.661
	Carbon M	.727	.889	.715	.686	.676	.671	.669
	Segregation	15.40	32.88	/ 10.51	2.85	1.96	1.36	1.21
H8	Carbon O	.649	.656	.657	.659	.654	.657	.....
	Carbon M	.758	.690	.673	.661	.662	.664	.....
	Segregation	16.80	/ 5.18	2.44	.30	1.22	1.07	.....
H9	Carbon O	.655	.662	.642	.639	.640	.649	.....
	Carbon M	.804	.742	.686	.658	.662	.674	.....
	Segregation	22.75	12.08	/ 6.85	2.97	3.44	3.85	.....
H10	Carbon O	.661	.638	.638	.643	.653	.643	.....
	Carbon M	.727	.717	.669	.667	.667	.660	.....
	Segregation	9.98	12.38	/ 4.86	3.73	2.14	2.64	.....
H11	Carbon O	.639	.643	.638	.636	.638	.620	.....
	Carbon M	.733	.674	.637	.653	.659	.655	.....
	Segregation	14.71	/ 4.82	.16	2.67	3.29	5.65	.....
H12	Carbon O	.700	.701	.695	.699	.712	.....	.....
	Carbon M	.743	.713	.712	.707	.702	.....	.....
	Segregation	16.14	1.71	2.45	1.14	−1.40	.....	.....
H13	Carbon O	.627	.645	.649	.657	.642	.651	.656
	Carbon M	.786	.739	.664	.667	.658	.666	.663
	Segregation	25.36	14.57	/ 2.31	1.52	2.49	2.30	1.07
H14	Carbon O	.655	.676	.692	.687	.683	.692	.682
	Carbon M	.839	.775	.711	.703	.693	.698	.696
	Segregation	28.09	14.64	/ 2.75	2.33	1.46	.87	2.05
H15	Carbon O	.691	.692	.696	.693	.689	.684	.....
	Carbon M	.758	.819	.761	.725	.719	.713	.....
	Segregation	9.70	18.35	/ 9.34	4.62	4.35	4.24	.....
H16	Carbon O	.685	.687	.693	.674	.683	.....	.....
	Carbon M	.776	.731	.689	.706	.715	.....	.....
	Segregation	13.28	/ 6.40	− .58	4.75	4.69	.....	.....
H17	Carbon O	.667	.675	.669	.657	.659	.659	.....
	Carbon M	.699	.705	.686	.688	.670	.687	.....
	Segregation	/ 4.80	4.44	2.54	4.72	1.67	4.25	.....

[a] The rails were broken at about 5-foot intervals for analysis in accordance with diagram to determine the top discard necessary to eliminate carbon segregation above 12 per cent. The point at which the segregation becomes less than this amount is indicated by "/" in the table.

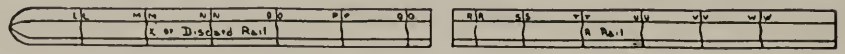
[b] H_{25} ingot

		Q
Carbon	O	0.590
	M	.702
Segregation		18.98

TABLE 19—Percentage Segregation of Carbon in the "A" Rails of Sink-Head Ingots—Continued

Ingot	Carbon	R	S	T	U	V	W	X
H18	Carbon O	0.672	0.672	0.672	0.662	0.676	.....	.....
	Carbon M	.771	.772	.712	.692	.669	.....	.....
	Segregation	14.73	14.88	5.95	4.53	−1.04	.....	.....
H19	Carbon O	.634	.631	.635	.631	.632	.....	.....
	Carbon M	.732	.701	.655	.654	.656	.....	.....
	Segregation	15.46	11.09	3.15	3.65	3 80	.....	.....
H20	Carbon O	.638	.661	.663	.660	.668	.....	.....
	Carbon M	.752	.686	.689	.684	.679	.....	.....
	Segregation	17.87	3.78	3.92	3.64	1.65	.....	.....
H21	Carbon O	.676	.674	.680	.668	.679	.....	.....
	Carbon M	.809	.707	.708	.692	.697	.....	.....
	Segregation	19.67	4.90	4.12	3.59	2.65	.....	.....
H22	Carbon O	.678	.671	.671	.674	.681	.....	.....
	Carbon M	.725	.680	.682	.688	.707	.....	.....
	Segregation	6.93	1.34	1.64	2.08	3.82	.....	.....
H23	Carbon O	.644	.655	.646	.647	.644	.....	.....
	Carbon M	.790	.703	.673	.669	.665	.....	.....
	Segregation	22.67	7.33	4.18	3.40	3.26	.....	.....
H24	Carbon O	.618	.628	.629	.626	.....	.....	.....
	Carbon M	.835	.791	.698	.657	.....	.....	.....
	Segregation	35.11	25.96	10.97	4.95	.....	.....	.....
H25	Carbon O	.596	.596	.599	.599	.591	.....	.....
	Carbon M	.633	.627	.625	.609	.609	.....	.....
	Segregation	6.21	5.20	4.34	1.67	3.05	.....	.....
H26	Carbon O	.657	.665	.658	.665	.660	0.661	.....
	Carbon M	.858	.760	.714	.685	.678	.689	.....
	Segregation	30.59	14.29	8.51	3.01	2.73	4.24	.....
H27	Carbon O	.655	.666	.654	.661	.650	.643	.....
	Carbon M	.722	.707	.662	.669	.656	.666	.....
	Segergation	10.23	6.16	1.22	1.21	.92	3.58	.....
H28	Carbon O	.642	.645	.657	.647	.649	.647	.....
	Carbon M	.749	.746	.689	.673	.665	.666	.....
	Segregation	16.67	15.66	4.87	4.02	2.47	2.94	.....
H29	Carbon O	.650	.646	.638	.654	.644	.....	.....
	Carbon M	.754	.682	.667	.671	.668	.....	.....
	Segergation	16.00	5.57	4.55	2.60	3.73	.....	.....
H30	Carbon O	.626	.637	.631	.636	.635	.....	.....
	Carbon M	.681	.666	.662	.661	.656	.....	.....
	Segregation	8.79	4.55	4.91	3.93	3.31	.....	.....
H31	Carbon O	.646	.643	.647	.655	.658	.650	.....
	Carbon M	.717	.679	.657	.646	.668	.665	.....
	Segregation	10.99	5.60	1.55	−1.37	1.52	2.31	.....
H33	Carbon O	.776	.675	.679	.672	.678	.....	.....
	Carbon M	.800	.729	.702	.706	.710	.....	.....
	Segregation	18.34	8.00	3.39	5.06	4.72	.....	.....
H34	Carbon O	.659	.655	.661	.665	.656	.....	.....
	Carbon M	.823	.725	.724	.723	.707	.....	.....
	Segregation	24.89	10.69	9.53	8.72	7.77	.....	.....
H35	Carbon O	.622	.633	.639	.639	.625	.633	.....
	Carbon M	.842	.684	.677	.663	.646	.647	.....
	Segregation	35.37	8.06	5.95	3.76	3.36	2.21	.....
H36	Carbon O	.634	.642	.654	.640	.648	.637	.....
	Carbon M	.796	.722	.655	.666	.649	.655	.....
	Segregation	25.55	12.46	.15	4.06	.15	2.83	.....

TABLE 20.—Percentage Segregation of Carbon in the "A" and Discard Rails of Comparison Ingots[a]



Ingot	Carbon	L	M	N	O	P	Q	R	S	T	U	V	W
M1	Carbon O	0.488	0.564	0.554	0.573	0.579	0.588	0.616	0.637	0.629	0.638	0.631	0.629
	Carbon M	.619	.630	.731	.848	.808	.791	.750	.740	.707	.683	.717	.662
	Segregation	26.84	11.70	31.95	47.99	39.55	34.52	21.75	16.17	12.40	7.05	13.63	/ 5.25
M2	Carbon O	.511	.558	.602	.622	.630	.644	.619	.641	...	...	...	...
	Carbon M	.886	1.086	.915	.898	.894	.878	.849	.811	...	...	...	...
	Segregation	73.39	94.62	51.99	44.37	41.90	36.34	37.16	26.52	/	...	...	...
M3	Carbon O	.600	.625	.635	.665	.663	.616	.667	.676	.673	...	...	...
	Carbon M	.774	.988	.889	.847	.810	.818	.792	.756	.708	...	...	...
	Segregation	29.00	58.08	40.00	27.37	22.17	32.79	18.74	/ 11.83	5.20	...	...	...
M4	Carbon O	.496	.630	.555	.626	.643	.664	.671	.659	.647	...	...	...
	Carbon M	.661	.704	.884	.900	.861	.808	.752	.669	.690	...	...	...
	Segregation	33.27	11.75	59.28	43.77	33.90	21.69	12.07	/ 1.52	6.65	...	...	...
M5	Carbon O	.589	.605	.621	.626	.652	.630	.647	.652	.658	.641	...	...
	Carbon M	.672	.777	.927	.919	.844	.786	.761	.700	.734	.721	...	...
	Segregation	14.09	28.43	49.28	46.81	29.45	24.76	17.62	7.36	11.55	12.48	/ ...	...
M6	Carbon O	.618	.648	.662	.666	.677	.674	.684	.683	.690	.684	.687	...
	Carbon M	.685	.701	.754	.783	.807	.769	.766	.769	.727	.764	.727	...
	Segregation	10.84	8.18	13.90	17.57	19.20	14.09	11.99	12.59	/ 5.36	11.70	5.82	...
M7	Carbon O	.640	.651	.662	.654	.666	.679	.678	.685	.689	.686	.677	...
	Carbon M	.670	.718	.769	.799	.788	.777	.764	.729	.719	.714	.704	...
	Segregation	4.69	10.29	16.16	22.17	18.32	14.43	12.68	/ 6.42	4.35	4.08	3.99	...
M8	Carbon O	.585	.666	.655	.657	.662	.667	.667	.697	.691	.691	.687	...
	Carbon M	.690	.667	.793	.805	.838	.797	.757	.732	.754	.727	.699	...
	Segregation	17.95	0.15	21.07	22.53	26.59	19.49	13.49	/ 5.02	9.12	5.21	1.75	...
M9	Carbon O	.626	.654	.671	.656	.700	.688	.699	.705	.706	.706	.703	...
	Carbon M	.545	.685	.746	.839	.841	.818	.800	.786	.764	.743	.735	...
	Segregation	−12.94	4.74	11.18	27.90	20.14	18.90	14.45	/ 11.49	8.22	5.24	4.55	...

[a] The rails were broken at about 5-foot intervals for analysis in accordance with diagram to determine the top discard necessary to eliminate carbon segregation above 12 per cent. The point at which the segregation becomes less than this amount is indicated by "/" in the table.

TABLE 20.—Percentage Segregation of Carbon in the "A" and Discard Rails of Comparison Ingots—Continued

Ingots	Carbon	L	M	N	O	P	Q	R	S	T	U	V	W
M11	Carbon O	0.703	0.723	0.724	0.712	0.701	0.717	0.705	0.688	0.693	0.689	.....	.....
	Carbon M	.770	.799	.770	.728	.758	.708	.698	.661	.669	.701	.....	.....
	Segregation	9.53	10.51	6.35	2.25	8.13	−1.26	−0.99	−3.92	−3.46	1.74	.....	.....
M12	Carbon O	.620	.671	.670	.701	.710	.699	.698	.692	.696	.680	.....	.....
	Carbon M	.816	.830	.871	.887	.806	.778	.745	.713	.672	.686	.....	.....
	Segregation	31.61	23.70	30.00	26.53	13.52	11.30	6.73	3.03	−3.45	0.88	.....	.....
M13	Carbon O	.697	.694	.711	.712	.716	.713	.720	.707	.724	.709	.....	.....
	Carbon M	.765	.776	.788	.750	.778	.765	.688	.707	.653	.640	.....	.....
	Segregation	9.76	11.82	10.83	5.34	8.66	7.29	−4.44	0.00	−9.81	−9.73	.....	.....
M14	Carbon O	.714	.711	.694	.700	.692	.705	.705	.706	.708	.682	0.701	.....
	Carbon M	.684	.742	.756	.781	.783	.776	.746	.736	.705	.679	.637	.....
	Segregation	−4.20	4.36	8.93	11.57	13.15	10.07	5.82	4.25	−0.42	−0.44	−9.13	.....
M15	Carbon O	.695	.690	.705	.693	701	.692	.685	.705	.712	.716	.704	0.663
	Carbon M	.664	.816	.797	.770	.815	.780	.722	.690	.696	.671	.677	.706
	Segregation	−4.46	18.26	13.05	11.11	16.26	12.72	5.40	−2.13	−2.25	−6.28	−3.84	6.49

A striking characteristic of this group (M11-M15) is the freedom from segregation in the A position; excluding M12 A for which the segregation is 32.52 per cent, the average for the others is about 2 per cent segregation at the A position (Table 16). M12 also possesses the following irregular segregation characteristics: At A there is segregation to such an extent that the steel is hypereutectoid; at B, a narrow hypereutectoid streak exists; at C there is the same structure as at A; and again at D a heavy hypoeutectoid streak.

(c) Segregation of Elements Other Than Carbon.—In general, it might be expected that the elements, sulphur and phosphorus, would follow carbon in segregation characteristics, and that manganese, silicon, chromium, and nickel would show little or no segregation. These expectations are borne out in both the sink-head and comparison ingots.

Longitudinal segregation of phosphorus is absent for the O position and slight for the M position. There is practically no longitudinal or transverse sulphur segregation in the sink-head ingots, while for the comparison ingots the results on sulphur segregation were erratic but on the whole follow that of the carbon. For the elements manganese, nickel, chromium, and silicon there is no well-defined segregation within the ingot.

7. Mechanical Tests

The mechanical tests included the ordinary drop test made on the first 5-foot piece below the top of the ingot showing physically sound steel. For the Hadfield rails this location was, in all but two cases, determined by the junction of sink head with the ingot proper. The 5-foot pieces formed by cutting up the A rails (also the X rail from the comparison ingots), as well as the test pieces, B, C, D, E (and F for the comparison ingots), were examined for hardness (Brinell and scleroscope) and behavior when stressed in tension.

(a) Method of Expressing the Results of Mechanical Tests.—It was thought best to express measurements, such as yield point, ultimate tensile strength, elongation, etc., in terms of the average and average deviation from the mean.[5]

When using the usual method of expressing results of this kind in terms of maximum and minimum values, undue emphasis is placed upon the occasional widely divergent figure, while the very close agreement that may exist is not brought to light. Graphic plots of the various physical properties of both kinds of steel will be found in Fig. 13 to 17, inclusive.

[5] The deviation of a single observation is the amount by which that observation departs from the mean or average value. By subtracting each observation from the mean without regard to sign, and averaging these, the average deviation from the mean is obtained.

Table 21.—Total Top Discard Required in Sink-Head Ingots[a]

Ingot	Weight of ingot	Bloom crop	Rail crop	Number of 5-foot pieces of rail	Length of cut	Amount of rail to cut	Rail discard, per cent of ingot	Bloom crop and rail discard	Total top discard required, per cent of ingot
	Pounds	Pounds	Feet		Feet	Pounds		Pounds	
H1	5300	190	5	3	20	667	12.6	857	16.2
H2	5300	155	5	2	15	500	9.4	655	12.3
H3	5300	205	11	1	16	533	10.1	738	13.9
H4	5350	270	5	3	20	667	12.5	937	17.5
H6	5300	324	5	1	10	333	6.3	657	12.4
H7	5250	234	5	2	15	500	9.5	734	14.0
H8	5300	142	10	1	15	500	9.4	642	12.1
H9	5300	294	5	2	15	500	9.4	794	15.0
H10	5250	320	5	2	15	500	9.5	820	15.6
H11	5300	325	8	1	13	433	8.2	758	14.3
H12	5350	204	10	0	10	333	6.2	537	10.0
H13	5300	191	5	2	15	500	9.4	691	13.0
H14	5300	231	5	2	15	500	9.4	731	13.8
H15	5300	167	5	2	15	500	9.4	667	12.6
H16	5350	199	9	1	14	467	8.7	666	12.4
H17	5300	145	10	0	10	333	6.3	478	9.0
H18	5300	237	5	2	15	500	9.4	737	13.9
H19	5300	160	9	1	14	467	8.8	627	11.8
H20	5300	276	9	1	14	467	8.8	743	14.0
H21	5300	442	5	1	10	333	6.3	775	14.6
H22	5250	437	5	0	5	167	3.2	604	11.5
H23	5350	134	8	1	13	433	8.1	567	10.6
H24	5300	185	9	2	19	633	11.9	818	15.4
H25	5300	160	10	0	10	333	6.3	493	9.3
H26	5300	160	8	2	18	600	11.3	760	14.3
H27	5300	245	8	0	8	267	5.0	512	9.7
H28	5300	233	5	2	15	500	9.4	733	13.8
H29	5350	566	5	1	10	333	6.2	899	16.8
H30	5300	247	8	0	8	267	5.0	514	9.7
H31	5300	234	7	0	7	233	4.4	467	8.8
H33	5300	228	8	1	13	433	8.2	661	12.5
H34	5300	195	12	1	17	567	10.7	762	14.4
H35	5300	280	5	1	10	333	6.3	613	11.6
H36	5300	342	5	2	15	500	9.4	842	15.9

[a] The above discard includes amount necessary to eliminate piping and segregation above 12 per cent

TABLE 22.—Total Top Discard Required in Comparison Ingots[a]

Ingot	Weight of ingot	Bloom crop	Rail crop	Number of 5-foot pieces of rail	Length of cut	Amount of rail to cut	Rail discard, per cent of ingot	Bloom crop and rail discard	Total top discard required, per cent of ingot
	Pounds	Pounds	Feet		Feet	Pounds		Pounds	
M1	7360	183	5	12	65	2167	29.4	2350	31.9
M2	7030	243	5	8	45	1500	21.3	1743	24.8
M3	7040	185	5	8	45	1500	21.3	1685	23.9
M4	7130	189	5	8	45	1500	21.0	1689	23.7
M5	7190	223	5	10	55	1833	25.5	2056	28.6
M6	7340	189	5	9	50	1667	22.7	1856	25.3
M7	7200	205	5	8	45	1500	20.8	1705	23.7
M8	7260	188	5	8	45	1500	20.7	1688	23.3
M9	7240	225	5	8	45	1500	20.7	1725	23.8
M11	7540	664	5	0	5	167	2.2	831	11.1
M12	7340	288	5	6	35	1167	15.9	1455	19.8
M13	7190	490	5	0	5	167	2.3	657	9.1
M14	7320	379	5	6	35	1167	15.9	1546	21.1
M15	7480	236	5	7	40	1333	17.8	1569	21.0

[a] The above discard includes amount necessary to eliminate piping and segregation above 12 per cent.

(b) Ultimate Strength and Yield Point.—The ultimate strength of the steel in rails from both type of ingots are of the same order of magnitude, about 125,000 pounds per square inch. For the 35-sink-head ingots

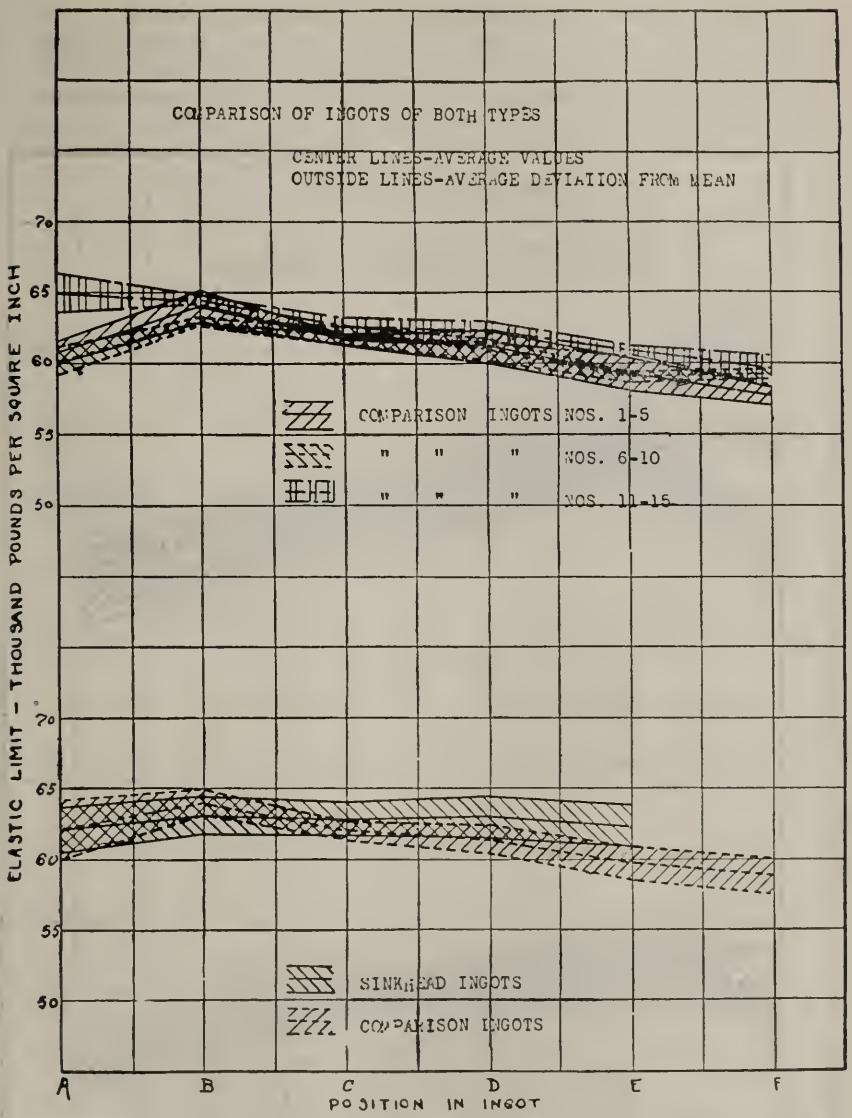


Fig. 13.—*Elastic limit of ingots of both types*

the non-uniformity, expressed as the average deviation from the mean for values at A, B, C, D, and E positions, is somewhat greater than for the comparison ingots, except for the A position, at which the results are erratic (Table 13 and 14).

If we consider the ultimate strength throughout the length of the ingot, we note for the sink-head ingots there is practical uniformity down to the E position; for the comparison ingots, on the other hand, there is an abrupt increase in ultimate strength from the A to the B position and a gradual falling off until the bottom of the ingot is reached, so that at

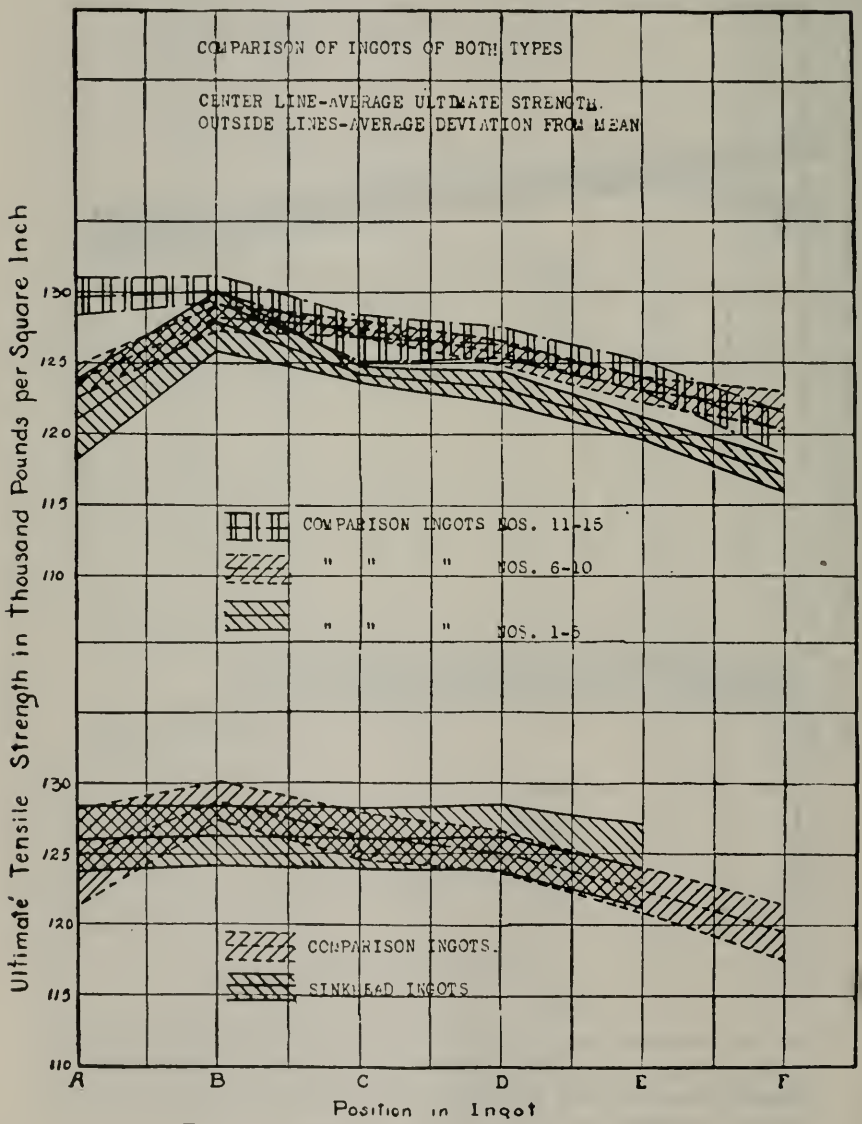


Fig. 14.—*Ultimate strength of ingots of both types*

the F position the ultimate tensile strength is some 9000 pounds per square inch less than the maximum at B.

If the comparison ingots are considered by groups corresponding to heats, it is seen that the ultimate strength of each group may be distinguished

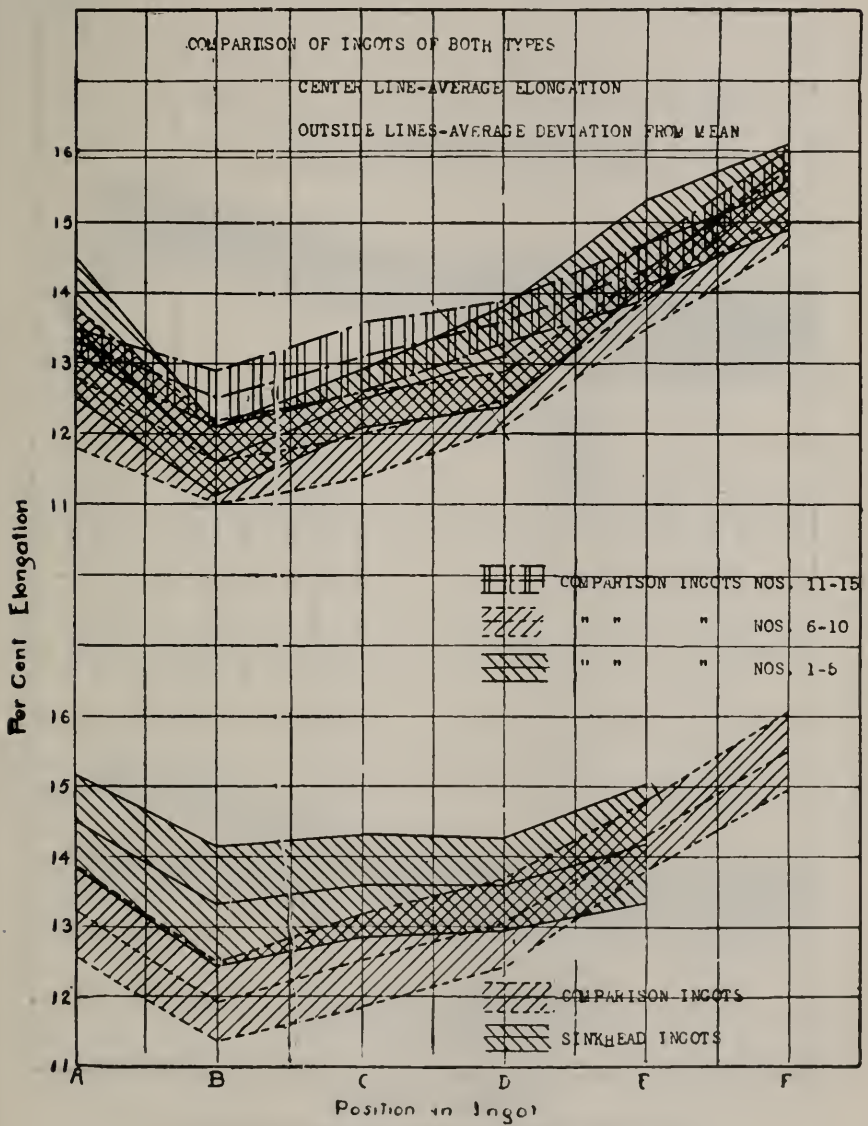


Fig. 15.—*Elongation of ingots of both types*

from the others. Thus groups M1-M5 and M6-M10 run closely parallel through the ingot, with M6-M10 having slightly higher ultimate strength. Group M11-M15 is characterized by the abnormally high value (approximately 130,000 pounds per square inch) in the A and B positions.

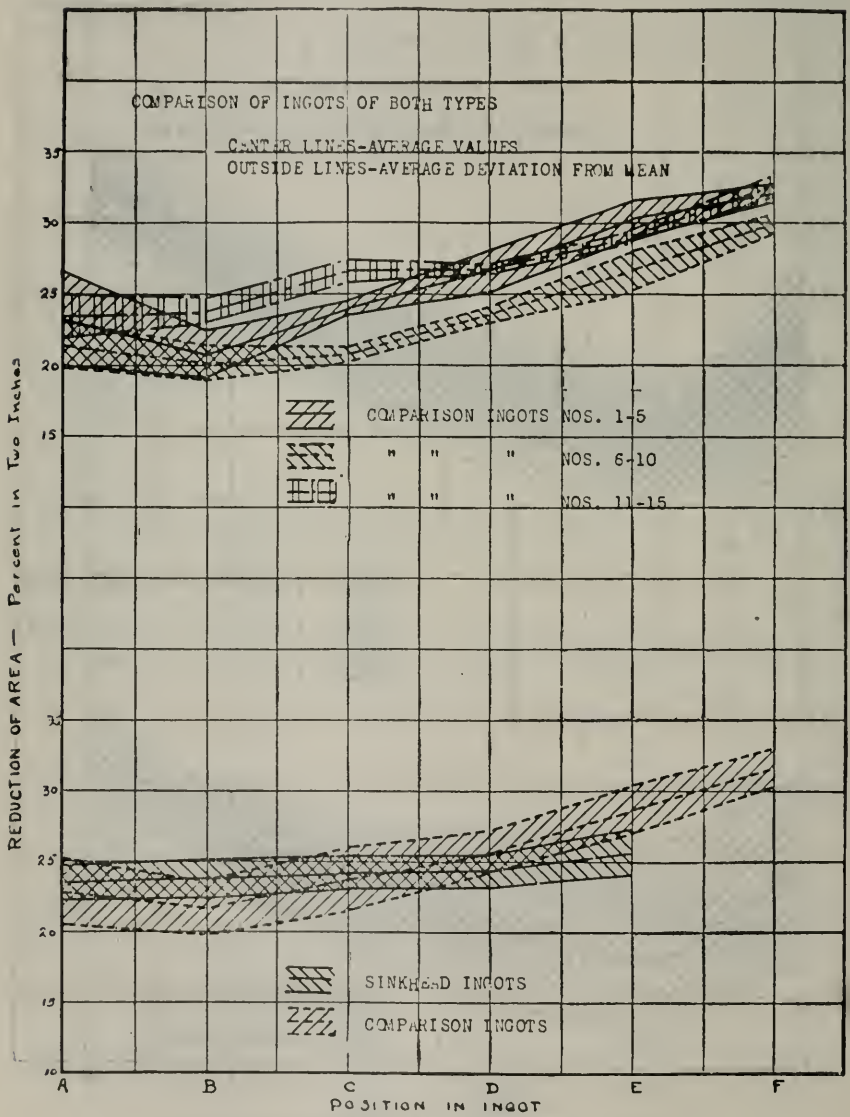


FIG. 16.—*Reduction of area of ingots of both types*

The yield point shows, in general, characteristics similar to the ultimate strength; for the former, however, there is a somewhat greater uniformity throughout the ingot for all types, and also for the ingots of a given group. The sink-head ingots have a slightly higher yield point (62,370 pounds per square inch) than the comparison ingots (61,370 pounds per square inch.).

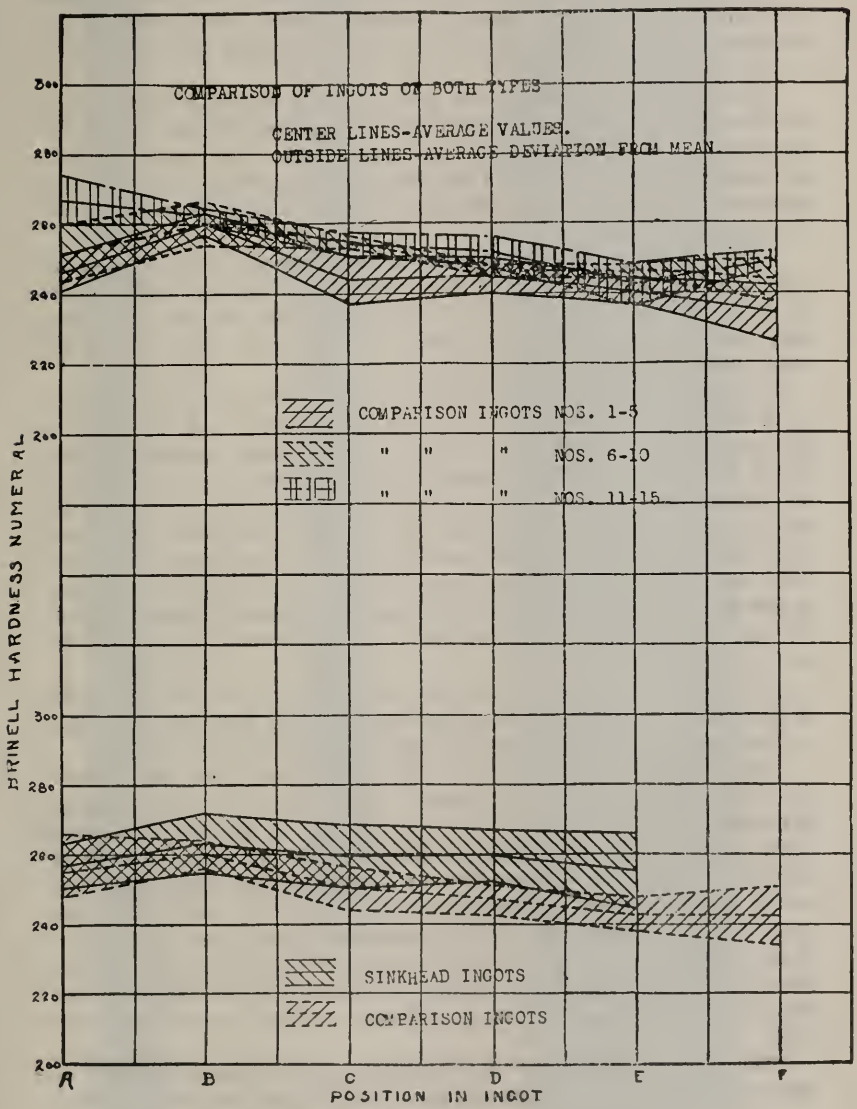


Fig. 17.—*Brinell hardness of ingots of both types*

For the three groups of the latter there is a falling off throughout the length of the ingot from approximately 64,000 to 59,000 pounds per square inch (as for the ultimate strength), while for the sink-head ingots the yield point remains practically constant throughout.

(c) Elongation and Reduction of Area.—The distribution of ductility, as measured by elongation in tension-test pieces from rails through the length of the sink-head ingots, is somewhat more uniform than for the comparison ingots. The elongation curves are practically the reciprocal of the tensile-strength curves.

The average elongation of the rails from the sink-head ingots is 13.8 per cent, of the comparison ingots 13.6 per cent; the reduction of area for the former type of ingot is 24.38 per cent, for the latter type it is 25.78 per cent, with a range of 21.73 per cent at B to 31.68 per cent at the F position. There are also considerable differences among the three groups of comparison ingots.

(d) Hardness.—The scleroscope hardness numbers do not appear to have any significance in defining any differences in qualities or properties in the steel of the several ingots. The material from the sink-head ingots have an average hardness of 31, while the steel from ingots cast in the usual manner has an average hardness of 32.

The Brinell numerals are, as would be expected, fairly closely proportional to the ultimate strengths, and they appear to follow even more exactly the yield points. Whether or no there is any definite relation between carbon segregation and Brinell numerals appears difficult to say. The holes for obtaining drillings for the former are one-half inch in diameter and not always exactly coincident in location with the Brinell impression. In a general way one would expect the two to bear some relation to each other. The rails from the sink-head ingots had an average Brinell hardness of 260 (deviation ± 8), while the rails made from ingots cast with the small end uppermost without sink heads had a Brinell hardness of 250 (deviation ± 6).

(e) Drop Tests.—In the drop tests blows were given on head of rail to destruction, the deflection was measured for each blow, the elongation for each inch over 6 inches and the total elongation noted.

The drop-test piece was taken from near the top of the ingot, and in each case was the first 5-foot length of rail immediately after reaching physically sound steel; that is, free from pipe and in the case of the rails from sink-head ingots also below the bottom of the sink head. Of the 14 comparison rails none broke under 4 or 5 blows (6 rails were nicked and broken after the fourth or fifth blow), while for the 35 Hadfield rails the range was 2 to 7 blows, there being 9 requiring 4 blows, and 4 requiring 3 blows; only 22, or 63 per cent, of the rails from sink-head ingots withstood 4 or more blows. The ductility as measured by the deflection and elongation is also somewhat greater and more uniform for the comparison rails.

The greater uniformity of the sink-head over the comparison ingots, as shown in nearly all other mechanical tests, in less segregation, greater homo-

Fig. 5.—*Photograph of sulphur print of top bloom from comparison ingot No. 10*

Fig. 6.—*Photograph of sulphur print of top bloom from sink-head ingot No. 5*

Fig. 7.—*Photograph of sulphur print of half section of sink-head ingot No. 32*

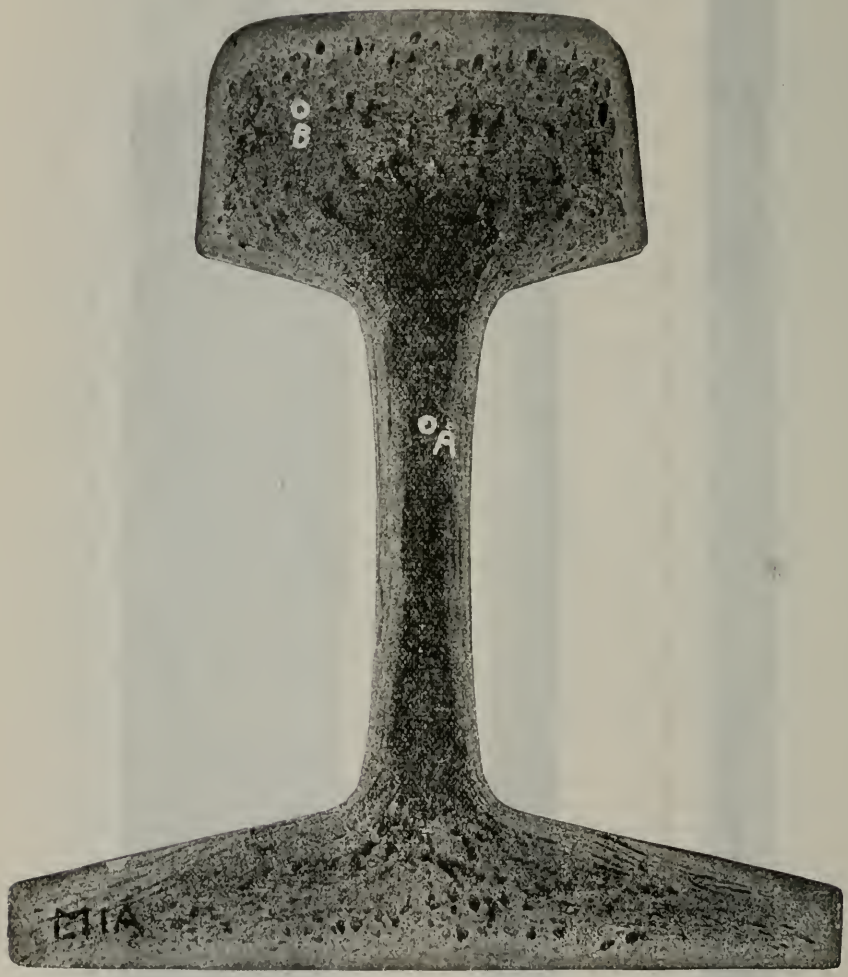
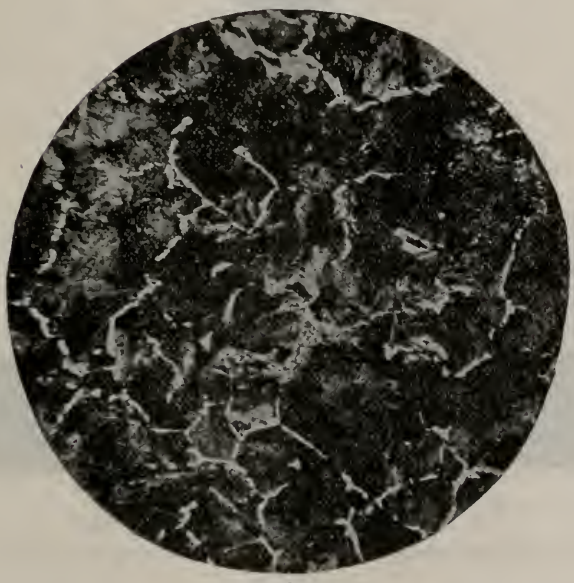


Fig. 8.—*Rail M1-A from comparison ingot*

Sulphur print, showing extreme segregation in rail from top of ingot. × 1

a



b

FIG. 8.—*Rail M1-A from comparison ingot (continued)*

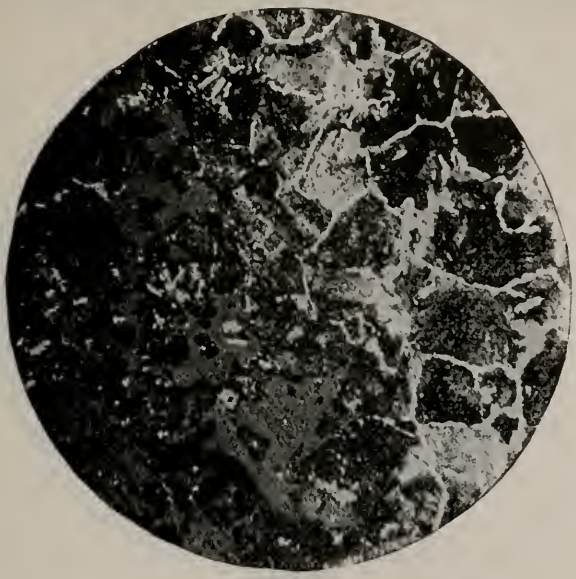
Typical microstructure of the metal of rail M1-A at positions indicated in sulphur print. × 50, reduced from × 100.

(*a*) Moderately finely grained hypereutectoid steel, pearlite with a trace of free cementite and many small slag inclusions.

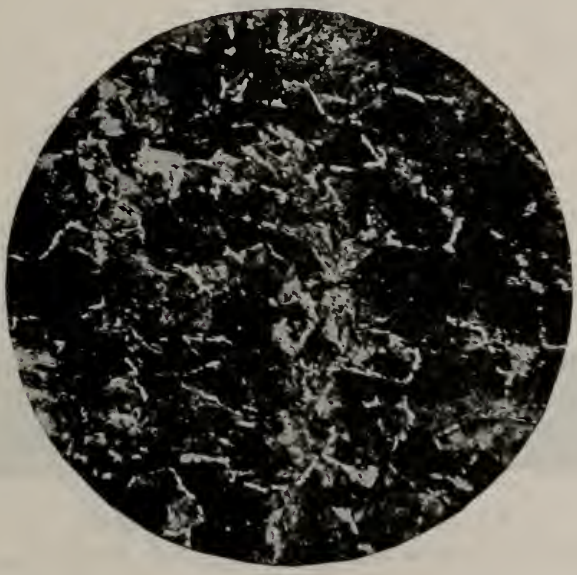
(*b*) Moderately finely grained hypoeutectoid steel, pearlite with a thick irregular ferrite network.

Fig. 9.—*Rail M5-F from comparison ingot*

Sulphur print, showing pipe in rail from bottom portion of ingot (F position). × 1



a



b

FIG. 9.—*Rail M5-F from comparison ingot (continued)*

Typical microstructure of the metal of rail M5-F at positions indicated in the sulphur print. × 50, reduced from × 100.

(*a*) Structure at the edge of a pronounced pipe, consisting of eutectoid steel contaminated with slag and bordered by a layer of hypoeutectoid metal.

(*b*) Moderately finely grained metal, consisting of pearlite with a trace of ferrite, and containing some slag intrusions.

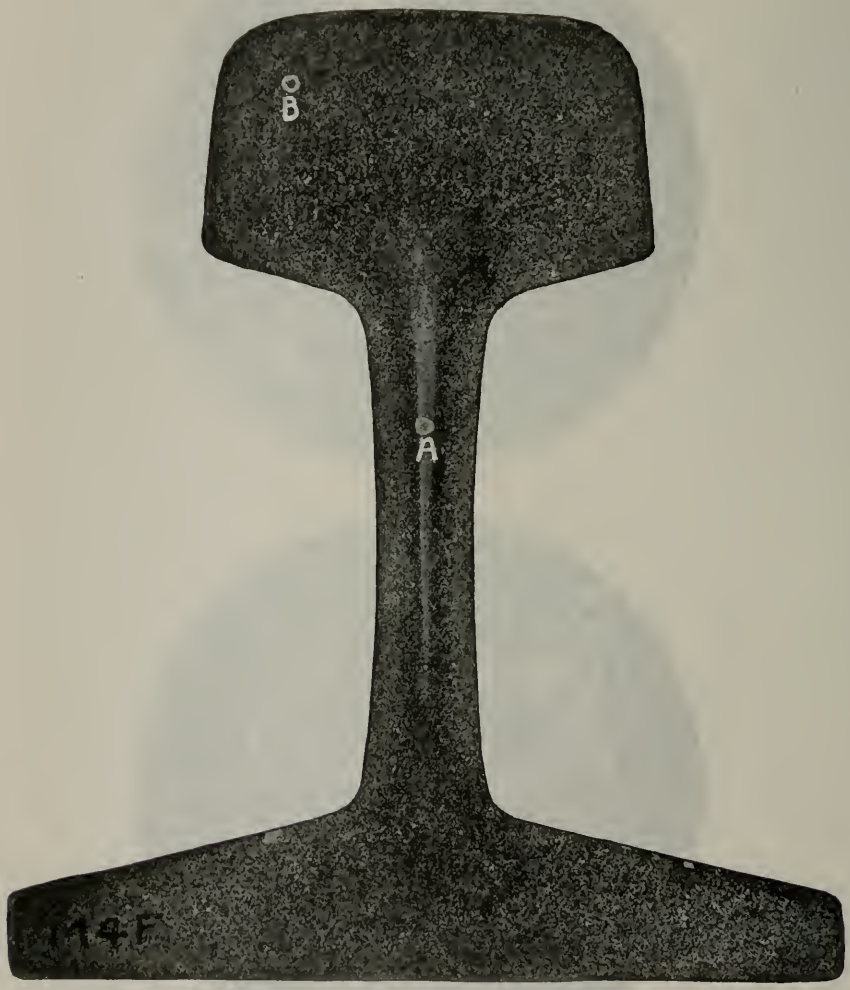
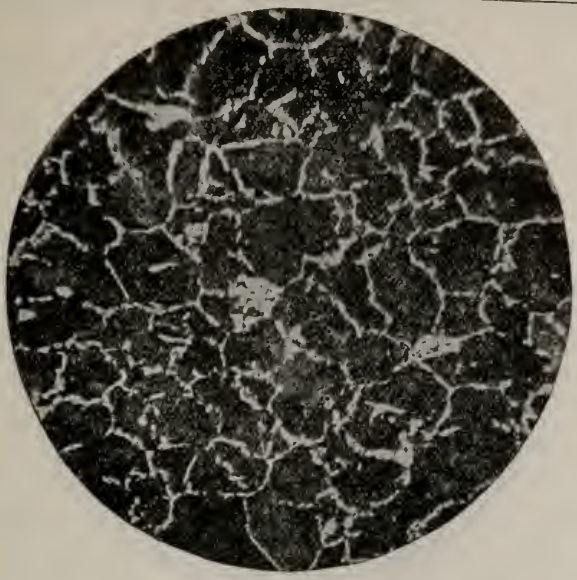
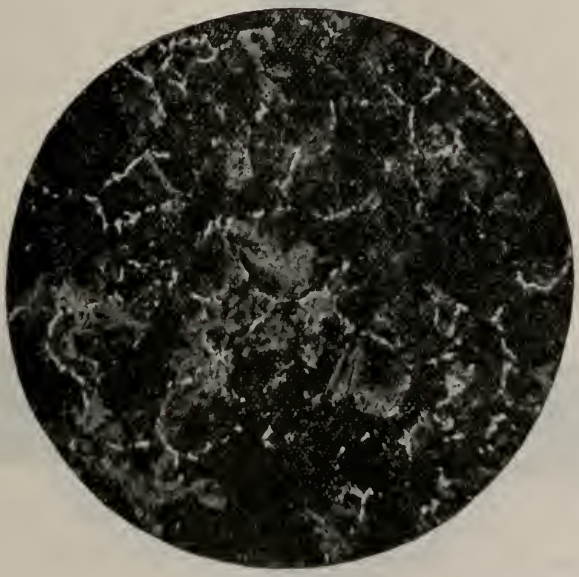


Fig. 10.—*Rail M4-F from comparison ingot*

Sulphur print, showing soft streak in web at F position (bottom of ingot). × 1



a



b

FIG. 10.—*Rail M4-F from comparison ingot (continued)*

Typical microstructure of the metal of rail M4-F at the positions indicated in the sulphur print. × 50, reduced from × 100.

(*a*) Streak of soft metal in the web, consisting of pearlite crystals surrounded by well developed ferrite envelopes.

(*b*) Moderately finely grained metal consisting of pearlite and a trace of ferrite.

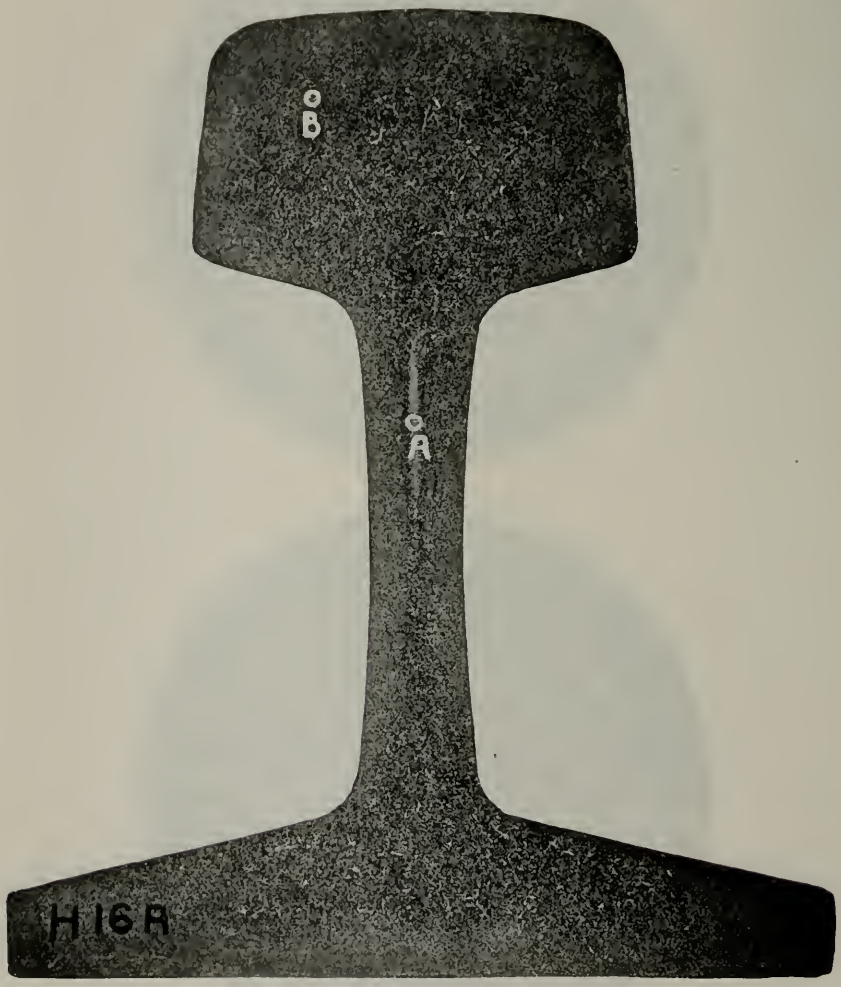
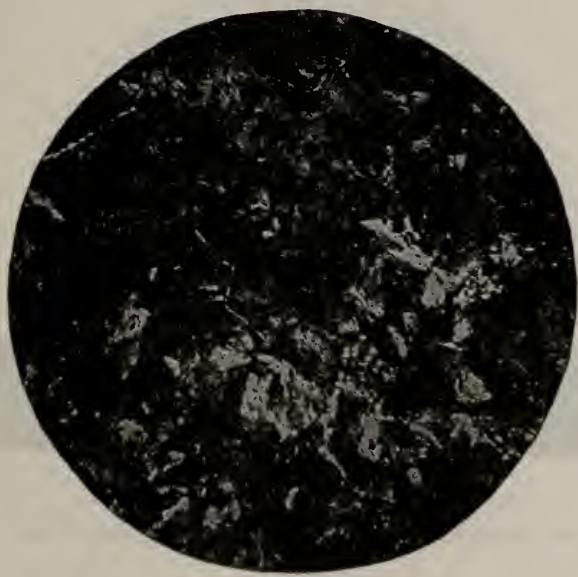


Fig. 11.—*Rail H16-A from sink-head ingot*

Sulphur print, showing slight segregation in upper part of ingot (A position). × 1

a



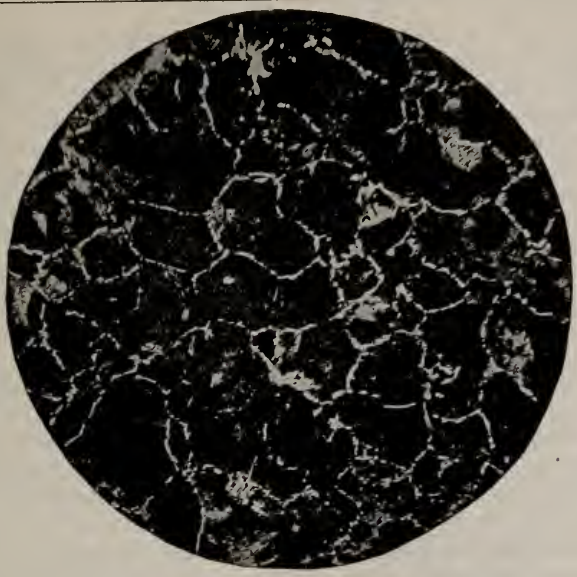
b

FIG. 11.—*Rail H16-A from sink-head ingot (continued)*

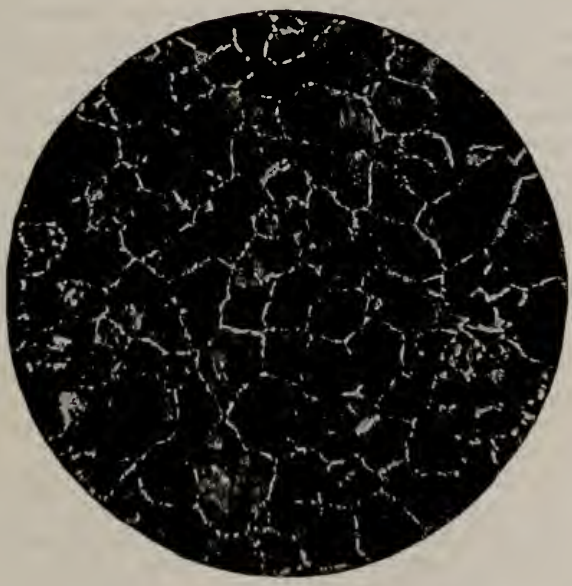
Typical microstructure of the metal of rail H16-A at positions indicated in the sulphur print. × 50, reduced from × 100.
(*a*) Eutectoid metal comprising a slightly segregated streak in the web of the rail.
(*b*) Average finely grained structure, pearlite with a trace of ferrite.

Fig. 12.—*Rail H16-E from sink-head ingot*

Sulphur print, showing sound steel in rail from bottom of ingot (E position). × 1. The rail is homogeneous.



a



b

Fig. 12.—*Rail H16-E from sink-head ingot (continued)*

Typical microstructure of the metal of rail H16-E at the positions indicated in the sulphur print. × 50, reduced from × 100.
(*a*) Moderately finely grained metal showing a thick ferrite network.
(*b*) Finely grained metal, pearlite with a ferrite network.

geneity as shown by sulphur prints and etching, less amount and variability in discard to sound steel, suggests that the question of the significance and interpretation of the drop test may well be raised with propriety. The greater ductility and more uniform behavior under the drop test of the steel from the comparison ingots would appear to be due more to the chemical composition, and especially to the nickel and chromium content of this Mayari steel, than to any factor traceable to manufacture, which in the case of the comparison ingots is seen to divide them sharply into three groups of very distinct physical characteristics—each a heat—which fact, the drop test is unable to reveal.

8. Metallographic Tests

The metallographic tests throw additional light on the question of segregation and soundness, and especially with reference to the presence of slag inclusions, streaks, and seams. They also furnish evidence as to the uniformity of the operations in the rolling mill, although there appears also to be a distribution of structure for each ingot characteristic of its manufacturing processes preceding the rolling.

The smoothness and evenness of tone of the sulphur prints of all rail sections from the Hadfield sink-head ingots, which are characteristic of the lot (Fig. 11-12), even from sections in the drop-test portion near the top of the ingot, is in striking contrast to the markedly irregular sulphur prints from comparison rails (Fig. 8, except for a few below the center of some of these ingots. Most of the rails from the Maryland ingots show very pronounced irregularities in terms of the sulphur prints, some of them from the bottom of ingot showing well-defined pipes (Fig. 9 and 10).

As to the microstructure of the steel, here again the sink-head ingots show much the greater uniformity. This is especially true for the upper portions of the ingot, where differences would be expected.

The parallelism of segregation and type of structure is, in general, very close. Thus in the extreme top portion of the ingot there appears a fine-grained, hypereutectoid structure in the segregated area. The main differences in structure across the section, except for these extreme cases accompanying marked segregation, are usually limited to differences in grain size, pearlite with a ferrite network, the smaller-sized grain accompanying the higher carbon. This is the predominant characteristic of the microstructure of the rails from the sink-head ingots.

The rails from the comparison ingots have, below the segregated area, about the same structural characteristics as those from the sink-head type, except that for many of them the ferrite network is less pronounced and in some cases almost absent. The rolling and finishing temperatures of the ingots were not widely different and do not appear to play any considerable role in determining differences of structure. The manganese content, usually somewhat higher in the Hadfield ingots, apparently tends to accentuate the

sharp, definite boundaries of ferrite surrounding the pearlite grains. A number of typical photomicrographs are shown in Fig. 8-12, inclusive.

9. Examination of Split Ingots and Blooms

(a) Sink-Head Ingot H37.—Sink-head ingot H37 was cut in halves at Sheffield and Sir Robert Hadfield reports:

The whole of this ingot could be worked into rails after cutting off 10 per cent discard. The ingot is perfectly sound and represents the average quality of the whole of the 36 ingots sent to be rolled into rails.

The capacity of the sink-head cavity of this ingot was 8125 cubic centimeters, and the percentage of settling, by weight in pounds—that is, of the total weight of the ingot—was 2.58 per cent. The weight of the material which passed from the head portion into the ingot itself was about 130 pounds. This ingot was selected because it showed the lowest cavity percentage; namely, 2.58 per cent.

(b) Sink-Head Ingot H32.—Sink-head ingot H32 was cut in halves at the Bureau of Standards. A photograph of a sulphur print of a longitudinal half section of the ingot is shown in Fig. 7. In Fig. 18-21, inclusive, are shown the location of drill holes for chemical analyses of this ingot, as well as the results of the analyses. Only carbon, phosphorus, silicon, and sulphur surveys were made, as the rail analyses indicated that there was no appreciable segregation of manganese in similar ingots. The results obtained indicate that with about 9 per cent discard, steel free from piping and appreciable segregation is obtained. Carbon showed a high degree of segregation (0.68 to 1.13 per cent), but as will be noted, this is confined to the extreme upper portion of the ingot. The high carbon content at this point is probably due to the fact that the steel in the top part of the ingot absorbed carbon from the charcoal used, together with air blast, to keep the ingot hot on its upper surface while cooling. Phosphorus, silicon, sulphur, and manganese are remarkably uniform in this sink-head type of ingot.

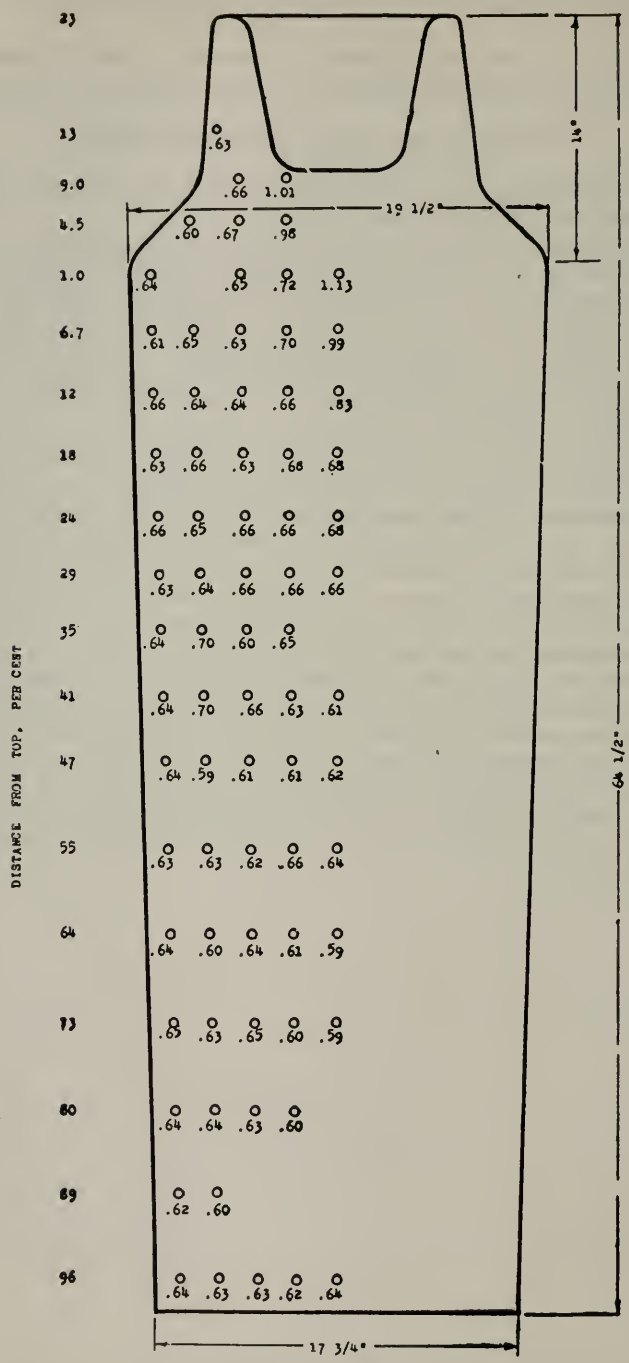


FIG. 18.—*Section of Hadfield split ingot No. 32, showing percentage of carbon*

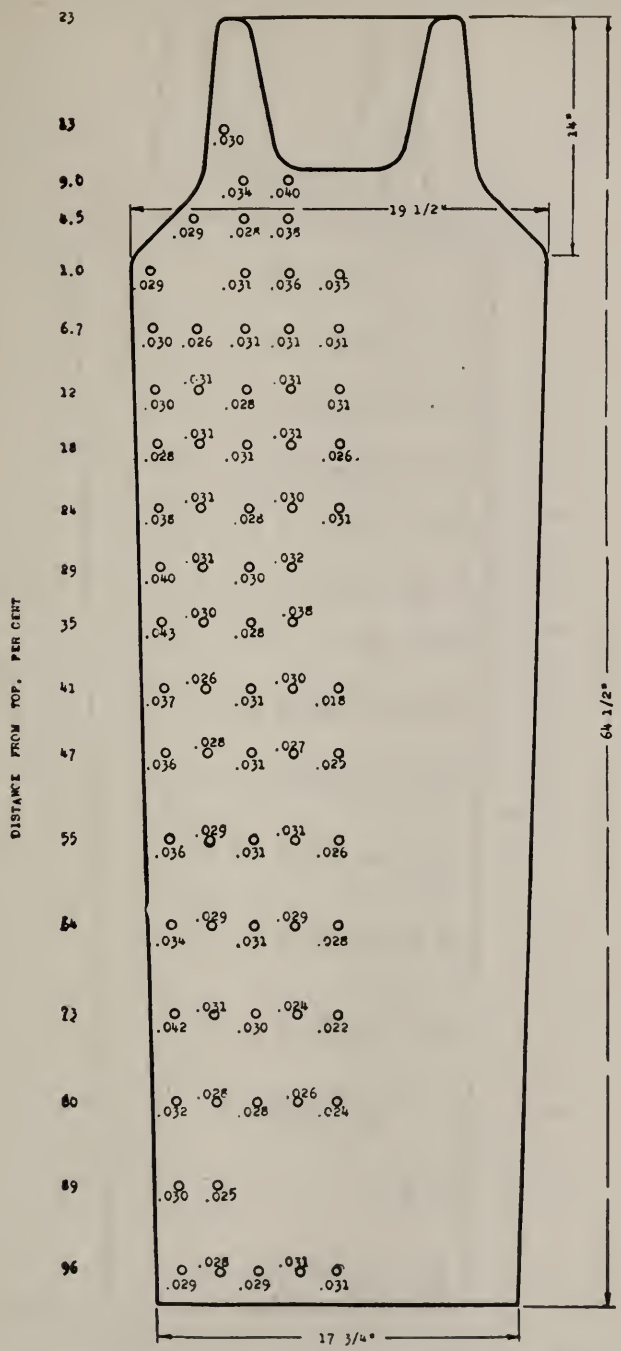


FIG. 19.—*Section of Hadfield split ingot No. 32, showing percentage of phosphorus*

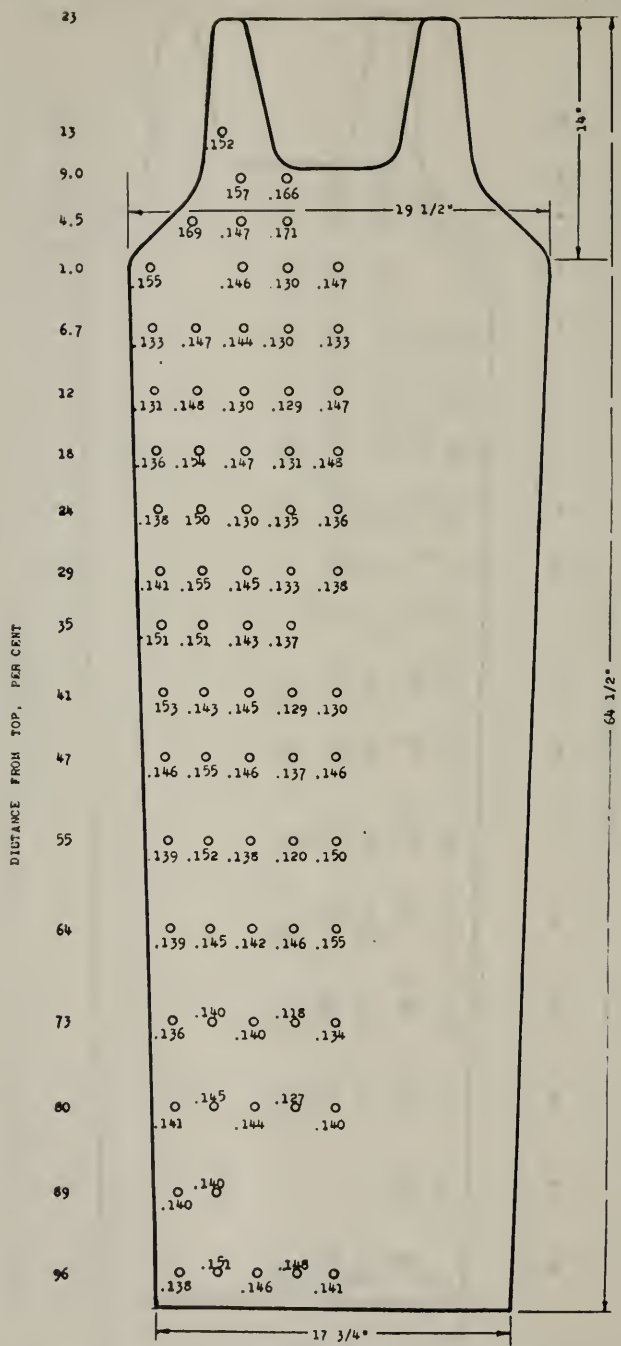


FIG. 20.—*Section of Hadfield split ingot No. 32, showing percentage of silicon*

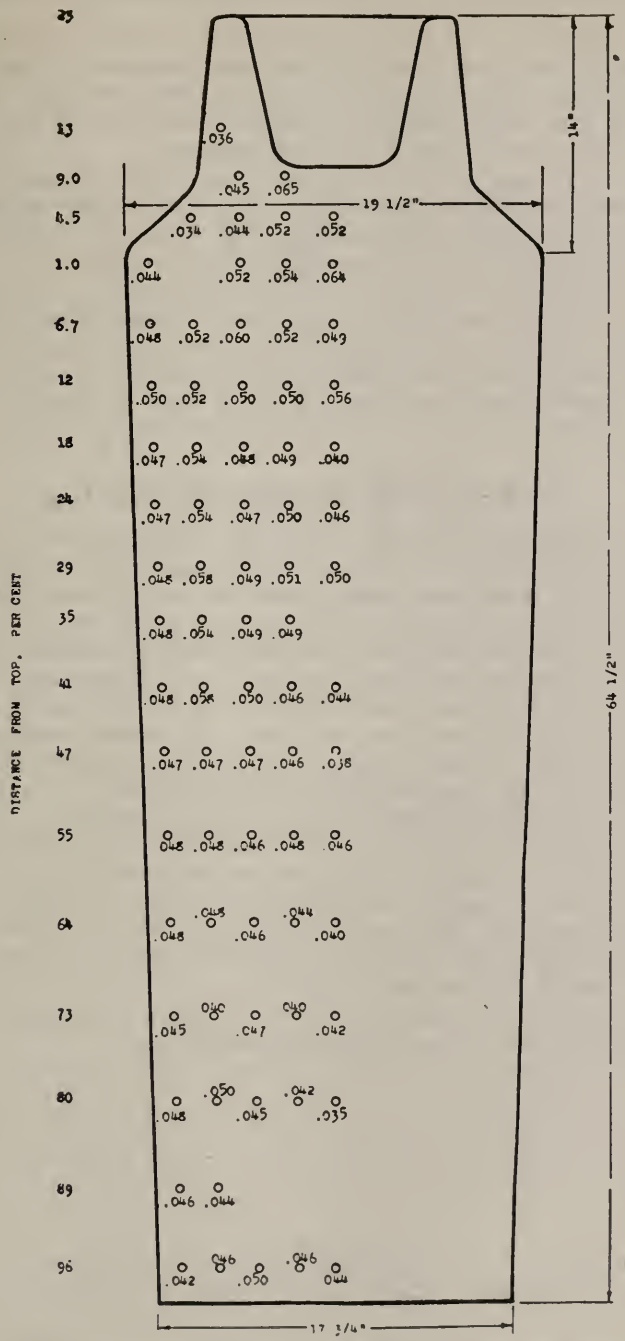


FIG. 21.—*Section of Hadfield split ingot No. 32, showing percentage of sulphur*

(c) Sink-Head Ingot H5 and Comparison M10 Top Blooms.—The top blooms from ingots H5 and M10 were split longitudinally at the Bureau of Standards and one half of each used for sulphur prints (Fig. 5 and 6) and the other half of each for a chemical survey (Fig. 22 and 23) of carbon, phosphorus, silicon, and sulphur segregation.

As in the case of the sulphur prints from the rails, the sulphur print from the bloom of the sink-head ingot is of even tone, while the comparison bloom shows decided irregularities (Fig. 5 and 6). In addition, the latter bloom has an inclosed pipe some 12 per cent below the top.

The chemical survey shows the Hadfield bloom to be very uniform. The maximum carbon is 0.90 per cent, and this is only 4 per cent from the top of the ingot. The comparison bloom, according to chemical analyses, is also quite uniform except for the sulphur content, which is very irregular. This element attains a maximum of 0.166 per cent at a distance of 12 per cent from the top, while it is as high as 0.12 per cent at a distance of 21 per cent.

10. Special Nickel Chromium Sink-Head Ingot

A special sink-head ingot, of the same dimensions and type as the other sink-head ingots but containing chromium and nickel, was rolled into rails so as to permit more accurate comparison with the ingots cast in the ordinary manner. The latter naturally contain small amounts of nickel and chromium from the Mayari ore from which the product was made.

The mechanical and chemical properties of the five rails from this special ingot (H38) are given in Table 23. It will be observed that the yield point (70,791 pounds per square inch), the ultimate tensile strength (143,025 pounds per square inch), and the Brinell hardness (292) are greater, while the elongation (11.3 per cent) and reduction of area (19.06 per cent) are less than those of the average sink-head ingot. Under the drop test the rails from this ingot behave similarly to the comparison ingots.

From the standpoint of composition the steel from this ingot differs from that of the average sink-head ingot in that it is of higher carbon (0.73 per cent) and lower phosphorus (0.016 per cent) and sulphur (0.018 per cent); also in that it contains small amounts of nickel (0.19 per cent) and chromium (0.11 per cent).

It was necessary to discard 17.6 per cent of this ingot because of pipe, as against 9.1 per cent for the average sink-head ingot.

TABLE 23.—Mechanical and Chemical Properties of the Special Sink-Head (Nickel and Chromium) Ingot

Rail	Tension tests				Hardness	
	Yield point	Ultimate strength	Elongation, per cent in 2 inches	Reduction of area	Brinell	Scleroscope
	Lbs./in.²	Lbs./in.²		Per cent		
H38-A	70 030	142 725	12	18.79	274	33
H38-B	70 700	143 400	11	18.59	298	32
H38-C	70 950	143 450	12	18.54	318	29
H38-D	71 445	143 300	11.5	18.38	283	33
H38-E	70 830	142 250	10	21.00	287	31
Average	70 791	143 025	11.3	19.06	292	32

Rail	Results of chemical analysis at "O"; per cent								
	Carbon			Mn	P	Si	S	Ni	Cr
	O	M	Seg.						
H38-A	0.741	0.741	0	0.91	0.024	0.179	0.018	0.19	0.10
H38-B	.731	.729	−0.27	.95	.027	.177	.019	.19	.10
H38-C	.728	.735	.96	.93	.026	.179	.018	.19	.12
H38-D	.734	.726	−1.09	.94	.027	.185	.018	.18	.10
H38-E	.731	.730	− .14	.96	.025	.180	.019	.19	.11
Average	.733	.732	− .11	.94	.026	.180	.018	.19	.11

IV. SERVICE OF RAILS FROM THIS INVESTIGATION

The Pennsylvania Railroad, through A. W. Gibbs, reports as follows on the service of the rails from the earlier investigation[6] and from the present one:

In January, 1915, the Maryland Steel Co. shipped free for test five No. 1 33-foot P. S. 100-pound open-hearth steel rails rolled from ingots furnished by Sir Robert Hadfield to the Bureau of Standards. These rails were laid in the Eastward freight track on Horseshoe Curve, January 20, 1915, and removed May 15, 1915. The average abrasion of the Hadfield rails was 1.16 square inches and that of the ordinary rail 0.78 square inch. None of these rails failed.

In September, 1915, the Maryland Steel Co. rolled 46 No. 1 and 61 No. 2 P. S. 100-pound rails (0.33 track mile) from imported Hadfield sink-head ingots and at the same time rolled 53 No. 1 and 4 No. 2 P. S. 100-pound rails (0.18 track mile) from its own ingots for comparison. The 46 No. 1 Hadfield and 53 No. 1 Maryland special rails were laid November 26, 1915, in the Eastward passenger and freight track on the 5° 30′ curves between Spruce Creek and Union Furnace, Middle Division, and removed October 23, 1916. The 61 No. 2 Hadfield and 4 No. 2 Maryland special rails were laid on a two-degree curve in the Eastward Low Grade track, Philadelphia Division, west of M. P. 69, and are still in track. The average abrasion of the No. 1 Hadfield rails was 0.42 square inch; that of the Maryland special rails 0.37. The rail on Low Grade was still in track October 31, 1919; abrasion was then 16.1 per cent for Hadfield and 9.7 per cent for Maryland special.

There have been no failures of Hadfield rails or of the Maryland specials.

There is evidently no economy in the Hadfield process as regards wear, and it would require a much more extended trial to determine the relative freedom from failure.

[6] See footnote 1.

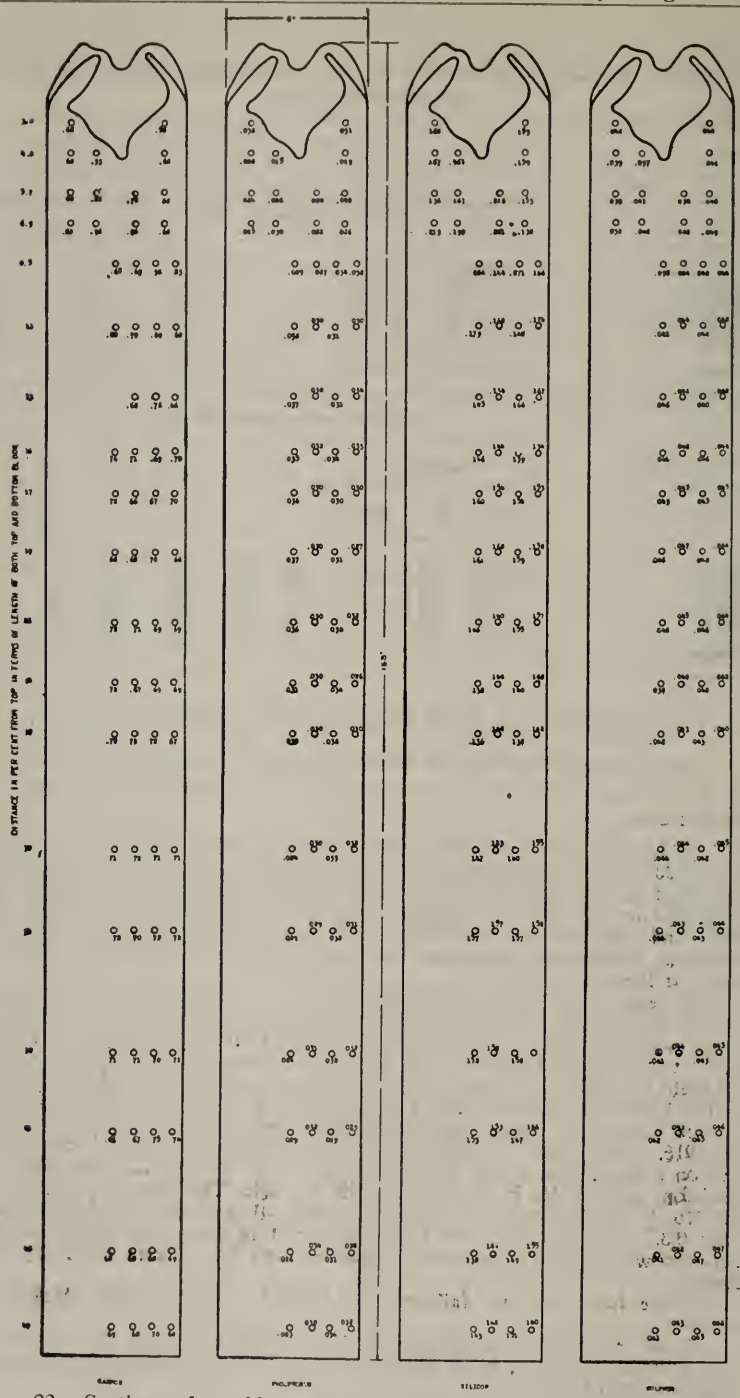


Fig. 22.—*Sections of top bloom from Hadfield ingot H5, showing chemical analysis of various positions.*

FIG. 23.—*Sections of top bloom from Maryland ingot M 10, showing chemical analysis of various positions.*

The Maryland rails may owe their less abrasion to their content of nickel and chromium. It would appear to be unfair to draw any general conclusions as to performance in service from so few rails as this investigation furnished, although it would not be expected that the Hadfield type of sink-head ingots would furnish any rails showing structural defects.

V. SUMMARY AND CONCLUSIONS

The object of this investigation was to determine the relation of ingot practice to the properties of rails from such ingots, and in particular the amount of total discard necessary to obtain rails free from piping and segregation above 12 per cent which had been rolled from steel made in accordance with varying melting, casting, and ingot practices.

To that end, 35 ingots made by the converter process at Hadfield's, Sheffield, England, and cast by the sink-head process with large end uppermost were shipped to Sparrows Point, Md., and rolled into rails in comparison with 15 rail ingots made in the ordinary manner with the small end uppermost. Each sink-head ingot, of 5300 pounds weight, and deoxidized with aluminum in the mold, represented a separate heat of converter steel, and all the heats and ingots were made in the same manner. The composition and properties of these ingots were of remarkable uniformity. The comparison ingots, of 7300 pounds each, were from three separate open-hearth heats, an intentional variation being made in the open-hearth and casting practice for each. Five ingots were selected from each of these three heats. Thus in reality, comparison was made of four different kinds of steel, of very nearly the same composition and physical properties and of two types of ingot form.

The comparison was made by rolling most of the ingots into rails and taking test specimens at each rail cut, as well as from a considerable portion of the upper part, in 5-foot steps, of the rail bar from each ingot. In this way there was obtained a detailed physical, chemical, and metallographic survey of each ingot, and it was possible to exactly delimit the regions of sound and homogeneous from those of unsound and segregated steel. Two complete sink-head ingots were cut longitudinally and examined, as well as representative blooms from both sink-head and ordinary ingots.

The results obtained indicate a decided superiority of the sink-head ingots over the comparison ingots as made of three grades of steel (Tables 17 and 18), although the sink-head ingots suffered from the disadvantage of having gone cold before rolling. The Hadfield type of ingot required a total discard of only 18.4 per cent on the average (13 per cent top discard to eliminate piping and segregation above 12 per cent) while the average ingot of the ordinary type for rails required a total discard of 43.9 per cent (26 per cent top discard), with great variations dependent upon the furnace and ingot practices.

The comparison ingots from heat M1-M5 of nondeoxidized rising steel, chilled on top of ingot by cast-iron caps, required excessive discard to eliminate positive segregation at the top and negative segregation at the

bottom of the ingot, the latter often accompanied by dangerous inclosed pipes.

The second heat (M6-M10) made of rising steel deoxidized with aluminum in the molds; the ingot tops of which were cooled with water, required the least total discard of the three heats. It was more subject to piping and less to segregation than the first heat of ingots made in the usual manner.

The third heat (M11-M15), made of quiet or "killed" steel, was not chilled on top with water or caps, and was deoxidized with aluminum in the molds. The ingots of this heat required an intermediate amount of total discard when compared to the first and second heats; this heat was the only one for which a greater top discard was required to eliminate piping than to eliminate segregation above 12 per cent. One of the ingot of this third heat contained a small pipe at the bottom, and all the rails from the middle and bottom of the ingots showed high negative segregation.

The variation of physical properties throughout the length of each ingot is characteristic not only of the type of the ingot, as sink-head or ordinary, but also of the state of the steel when cast and of the ingot practice.

It has been established in the foregoing that, after removal of the top discard of 13 per cent, the Hadfield type of sink-head ingot is free from piping and undue segregation. The ordinary type of ingot, cast small end up without sink head, as is usual for rail ingots, requires an average top discard of 26 per cent, and the remainder of the ingot is liable to contain inclosed piping and excessive segregation. Defective rails, from the middle and bottom portion of the ingot, are not detected with certainty by means of the test for existing rail specifications, and as a result of this uncertainty rails containing pipes or excessive segregation may get into service with disastrous results.

The surface condition of the rails from the sink-head ingots was not as good as that of the ordinary ingots, but this is not considered an essential characteristic of rails from such ingots.

The markedly differing characteristics of the three heats of comparison ingots lead one to raise the question whether or not it might be advisable to specify, at least in some degree, the methods of steel manufacture or of ingot practice for rails and similar products on which the safety of the traveling public depends.

While it is not claimed that the use of the sink-head process for the manufacture of ingots will solve all rail problems, it is maintained that its adoption would be a step in the right direction in view of the present heavy casualties and property losses on American railroads. The necessary changes in mill operations, it is believed, could be made without too great difficulties.

The service results, showing no failures to date, in the few rails of this investigation can not be considered conclusive one way or another.

It would be of the greatest practical importance in tracing statistically the origin of rail failures, if, in the reports to the Rail Committee of the American Railway Engineering Association, they be grouped with refer-

ence to their position in the ingot, and in addition the steel manufacturing process be reported at least briefly by such notations as rising steel capped with plates; quiet steel deoxidized with x ounces of aluminum per ton, etc. If then it be found, for a given kind of steel, there is a greater or less tendency for certain types of failure to predominate or to exist in certain definite regions in the ingot, corrections could then be made intelligently in the manufacturing process. The results of the present investigation indicate very strongly that one should expect the four types of steel and two types of ingot examined, in view of their sharply differing characteristics, to behave differently in service.

TRAFFIC CAPACITY OF A RAILWAY

By H. Parodi

Consulting Engineer, Paris-Orleans Railway, France

An analysis of the operating statistics of a railway from the point of view of regularity of train movements shows that for various reasons independent of one another, the time required to pass over a given section is not the same for all trains.

Some trains gain while others lose time, and if we class the actual times of train movements (road time) of trains of same category in the order of increasing duration, we find that the statistical curve of duration of train movements of classified trains has a form like the curve of Fig. 1.

This is the curve which may be obtained by the superposition of a series of cardboard strips each of which is as long, proportionately, as the duration of given train movements.* This curve, like all analogous statistical curves, is of a form which approaches more closely the curve based on the calculus of probabilities, the greater the number of trains considered.

By definition, this curve is of such a form that the ordinate Y of a point P corresponding to a road time X represents the number of trains for which the road time is *more* than X.

If X_m is the average road time and x the difference between X and X_m we can assume that the difference

$$x = X - X_m$$

will be distributed according to the law of Gauss (Fig. 2).

If this is true, the number of trains dY of which the road time differs from the average road time X_m by a quantity comprised between the limits x and $x + dx$ will be equal to

$$dY = \lambda e^{-\mu^2 x^2} dx$$

considering the origin to be at X_m. The parameters λ and μ depend on the number of trains in service and on the operating method followed.

If the number of trains is Y this number will correspond to the sum of all the differences possible and we should have

$$Y = \int_{-\infty}^{+\infty} \lambda e^{-\mu^2 x^2} dx = \frac{\lambda \sqrt{\pi}}{\mu}$$

$$\lambda = \frac{Y \mu}{\sqrt{\pi}}$$

On the other hand, we know that if x_0 designates the probable difference of the total of the statistical quantities considered, the number of trains for which the road times are between X_m and $X_m + x_0$ or between X_m and $X_m - x_0$ will be equal to $\frac{Y}{4}$.

*See Proceedings A.R.E.A., Vol. 22, page 757.

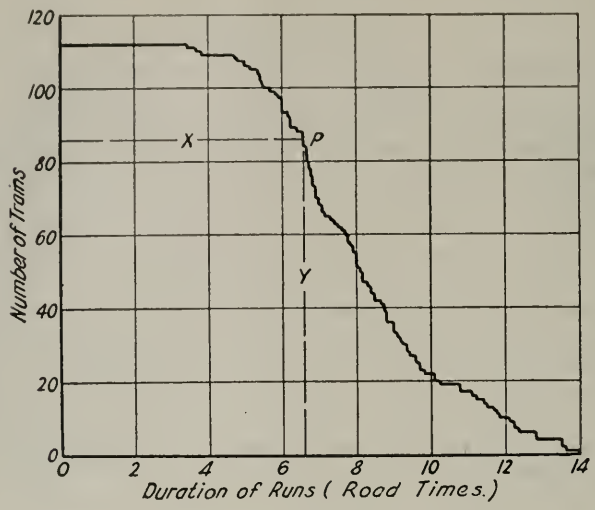

120
100
80
60
40
20
0
Number of Trains
X
P
Y
0
2
4
6
8
10
12
14
Duration of Runs (Road Times.)

Fig. 1

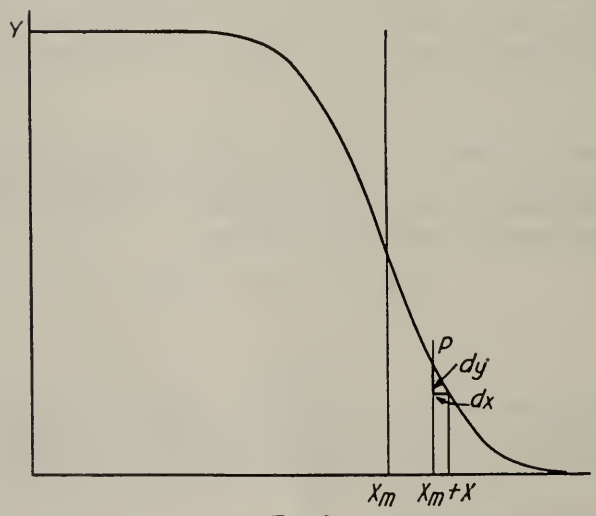

Y
P
dy
dx
Xm
Xm+X

Fig. 2

The probable difference x_o is by definition such that

$$\int_{-x_o}^{+x_o} \frac{Y\mu}{\sqrt{\pi}} e^{-\mu^2 x^2} dx = 0.5Y$$

and we find by the numerical solution of this equation that

$$x_o = \frac{0.4769}{\mu} \text{ or } \mu = \frac{0.4769}{x_o}$$

The numerical study of the Gauss integral shows that if the law of probability is observed, the number of trains where road time is comprised:

between X_m and $X_m + x_o$ or between X_m and $X_m - x_o$	should be by definition $0.250Y$
between $X_m + x_o$ and $X_m + 2x_o$ or between $X_m - x_o$ and $X_m - 2x_o$	should be by definition $0.161Y$
between $X_m + 2x_o$ and $X_m + 3x_o$ or between $X_m - 2x_o$ and $X_m - 3x_o$	should be by definition $0.067Y$
between $X_m + 3x_o$ and $X_m + 4x_o$ or between $X_m - 3x_o$ and $X_m - 4x_o$	should be by definition $0.0182Y$

We see that if horizontal lines having the following ordinates:

$$\frac{Y}{2}$$

$$\frac{Y}{2} \pm .250\,Y \qquad \frac{Y}{2} \pm .478\,Y$$

$$\frac{Y}{2} \pm .411\,Y \qquad \frac{Y}{2} \pm .4962\,Y$$

are drawn they will intersect the curve in nine points the abscissas of these intersections will be in arithmetical progression (see Fig. 3).

The reason for this constant progression between successive abscissæ is because x_o is by definition the probable difference of all the road times under consideration. This method of construction enables us on the one hand to determine the probable difference (P.D.) and on the other hand to ascertain whether the law of Gauss is or is not followed.

Fig. 4 is a copy of a train hour diagram prepared from data submitted to the Eight-Hour Commission and published by the American Railway Engineering Association. This diagram gives the road time for all the trains operated during a two weeks' test period (Curve 1) as well as the times the trains were actually moving (Curve 2) and likewise the time the crews were actually on duty (Curve 3).

*The application of the above method shows that the (P.D.) for Curve 1 for an average road time of 8.025 hours is 1,375 hours or 17.20

*From Curve 1, hours corresponding to 84 trains (.75x112) are 6.65 and the hours corresponding to 28 trains (.25x112) are 9.4 and half the difference $2.75 \div 2 = 1.375 =$ P.D. $= x_o$. Likewise from Curve 2 the hours corresponding to 84 and 28 trains are 4.7 and 6.1 respectively and the difference $1.4 \div 2 = .7 = x_o$. (Ed.)

per cent. From Curve 2 for the time the trains are actually moving the P.D. or x_0 is .7 hours or 13 per cent of the average time 5.4 hours.

These P.D.'s are considerable and much greater than those observed in Europe. An examination of Swiss statistics shows a much smaller average P.D. The number of delays of trains in excess of 10 minutes for passenger trains and in excess of 15 minutes for mixed trains has been, in 1912, 6900 for a total of 732,572 trains. By using the statistics of train movements and the timetables it is possible to deduce from the R-Ts of these trains, that the P.D. is about 4 per cent.

Combination of Probable Differences (P.D.)

It can be demonstrated in the calculus of probabilities that, if the law of Gauss is applicable, the P.D. of a sum of two measurements $x + y$ is

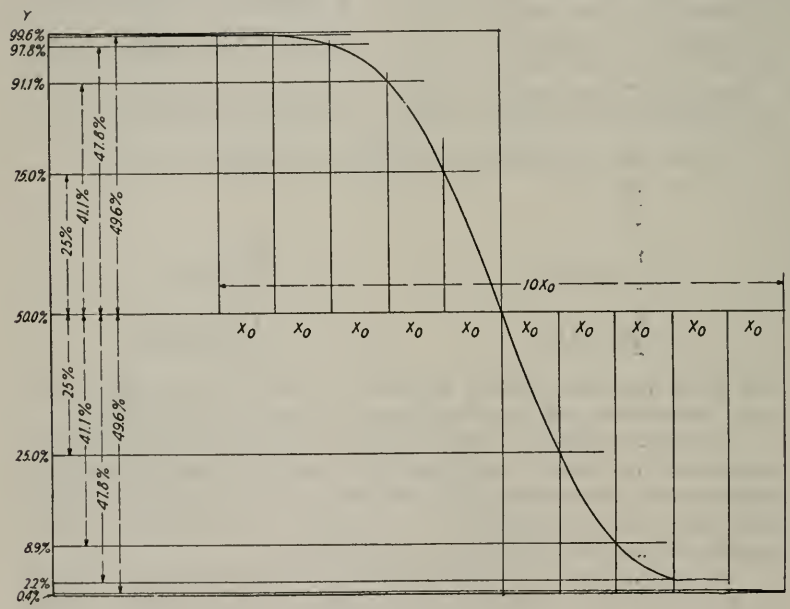


Fig. 3

equal to the square root of the sum of the squares of the P.D.'s of each of the measurements, that is,

$$\Sigma x + y = \sqrt{\Sigma x^2 + \Sigma y^2}$$

or, in a more general way, we may write:

$$\Sigma x + y + z + \ldots = \sqrt{\Sigma x^2 + \Sigma y^2 + \Sigma z^2 + \ldots}$$

The total time of a train run between two successive starts, road time (R-T) being equal to the sum of the running time and the times when the train is stopped or maneuvering, the P.D. of the R-T will be equal to the

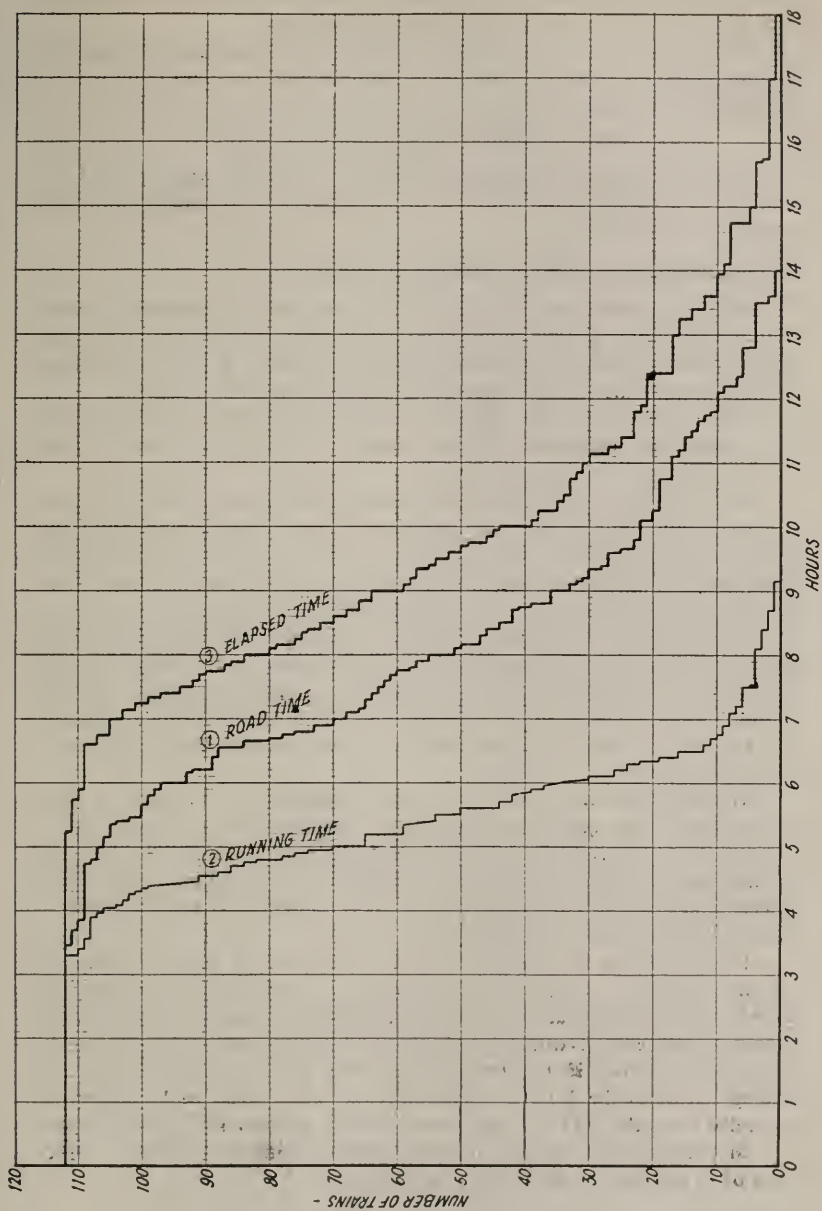

③ ELAPSED TIME
① ROAD TIME
② RUNNING TIME
HOURS
NUMBER OF TRAINS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
0
10
20
30
40
50
60
70
80
90
100
110
120

FIG. 4

square root of the sum of the squares of the P.D. of the running time and the P.D. of the maneuvering and stopping time.

The curve of Fig. 4 showing a P.D. of 17.3 per cent of the R-T and a P.D. of 13 per cent of the actual running time, the P.D. of the remaining time can be deduced:

$$\Sigma o = \sqrt{(.172)^2 - (.130)^2} = .11 \text{ or } 11\%$$

If a line consists of n, identical divisions for each of which the P.D. of the R-T is Σ, the P.D. of the R-Ts for n division is, by application of the preceding rules, $\Sigma \sqrt{n}$.

Determination of Probable Differences (P.D.s)

It results from what precedes that it is possible to calculate, a priori, the P.D. of the R-T, by analysis of the various causes of delays, determining for each of them the corresponding P.D. of the R-T and by combining these by the method of the square root of the sum of the squares.

With direct and single phase electrical traction the variation in R-T may result from variations in line voltage, in rolling resistance, in load and in the ability of the engine driver.

With three-phase or mono-three-phase electrical traction the variations in road times (R-Ts) can only result practically from variations in frequency at power stations. It is for this reason, in the writer's opinion, that these modes of traction should be considered as giving more "promise" than the others, although they do not permit making up of lost time.

Steam traction is certainly much less "precise" than electrical traction because of the greater number of causes for variation in different train runs. The power available at any given instant in a steam locomotive depends, in fact, on the method of firing the boiler from the start, on the quality of the fuel and on the professional ability of two men instead of one, as in electrical traction.

Whatever system of traction is used apparently no attention is paid, in practice, to the question of "precision." Nothing more is done than to determine for a given train run the desired margin of limiting load and station stop as could be rationally determined by systematic measurements which would furnish an approximate value of the probable difference of each of the elements of the problem.

From this rate it would be possible to deduce the probable difference of the component system and by making up timetables for train runs based on the theoretical times increased by eight times the corresponding probable difference it would be possible in 99 cases out of 100 to keep to the timetable, even if the train loads attain the permissible limits. By adding ten times the P.D. the probability of delay would be 1 in 1000 and if twelve times the P.D. is added the probability of delay is 1 in 10,000 trains.

In general, the increase of eight times is sufficient because a precision of 1 per cent is satisfactory in practice.

OPERATION OF SINGLE TRACK LINES

Consequences of Irregular Operation on the Train Capacity of the Line

Consider the theoretical case of a single track line with equidistant sidings and constant speed trains as shown by the graphic timetable, Fig. 5. The maximum number of trains which can be sent over the line is that corresponding to the complete utilization of all sections; it is evident that the number of train hours corresponding to this graphic is constant whatever the speed and, consequently, the number of trains sent out.

If x is the time taken to run over each section at the assumed speed, the time interval between two consecutive trains in the same direction will be a minimum of $2x$. In the time period T (24 hours, for example), the number of trains sent out in each direction will, therefore, be equal to $T/2x$ and for both directions $2T/2X = T/x$. The duration of the occupation of the line by each train being equal to nx, if there are n sections, it is evident that the number of train-hours, that is, the total time of occupation of the line by the trains sent over it, will be:

$$\frac{T}{x} n x = Tn$$

which quantity is independent of x and, consequently, of the speed of the trains.

If we assume that the trains stop a time x' at every siding the result is the same as if the running speed is reduced by a quantity such that x is replaced by $x + x'$. The time interval between two consecutive trains will be equal to $2(x + x')$ and it will be found, as in the preceding case, that the total maximum time of occupation of the line is equal, in both directions, to

$$2 \frac{T}{2(x + x')} (x + x') n = Tn$$

Whatever type of graphic is considered, if it is assumed that all the trains run to the same timetable, it will be found always and for both directions that the number of train hours is constant and equal to Tn.

If, therefore, we divide by two the time one train occupies the line, we double the number of trains which can circulate on the line in the same given time.

Consider the same theoretical line and suppose that we wish to make up a graphic, Fig. 5, with real trains subject to operating conditions so that the service shall not be disturbed for more than 1 per cent of the time.

Assuming always:

x = the minimum time of the run.
x_0 = the corresponding probable difference (P.D.).
χ = the duration of stops for maneuvering and for security of operation.
χ_0 = the corresponding probable difference (P.D.).

The P.D. in time for running over one section will be:

$$\sqrt{x_o^2 + \chi_o^2}$$

and for all the n sections:

$$\sqrt{n\,(x_o^2 + \chi_o^2)}$$

If it is desired to obtain a "stable" graphic or one which can be realized in practice, it will be necessary that intervals between trains on a section shall be calculated to permit of these differences without disturbing train circulation.

This condition will evidently be fulfilled in 99 cases out of a 100, if the actual duration of occupation of the section reserved for each train is

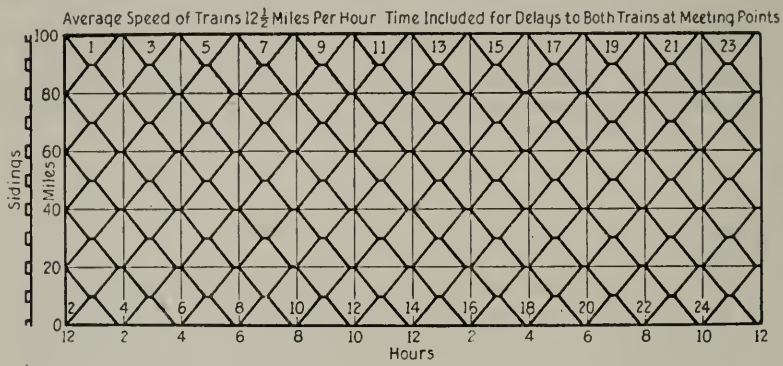


Fig. 5

equal to the average duration of the run increased by four times the component probable difference.

x and χ being the minimum practical times for the runs and for the stops, the average duration of runs and stops will be:

$$(x + \chi)_m = x + \chi + 4\sqrt{x_o^2 + \chi_o^2}$$

If the times of occupation of each section provided for on the graphic are equal to

$$x + \chi + 8\sqrt{x_o^2 + \chi_o^2}$$

there will be, on an average, only one disturbance for 100 train operations.

We propose to apply these considerations to the case of a theoretical graphic corresponding to a line with n equidistant sidings (every 12 Kms.) with trains running at 15, 22.5 and 45 Kms. an hour (Table 1).

For each of these train speeds we shall assume:

(a) that the minimum time for stops in each siding is 2 minutes with a P.D. of:

0 minute for case 1
0.5 minute for case 2
1 minute for case 3
2 minutes for case 4

Table 1

APPLICATION OF THEORY FOR DETERMINING THE UTILIZATION OF A SINGLE TRACK LINE

Speed (Km. per hour)	= 15				= 22.5				= 45			
Minimum duration of train movement (12 Km.)	= 48 minutes				= 32 minutes				= 16 minutes			
Minimum duration of stops	= 2 minutes				= 2 minutes				= 2 minutes			
CASE	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
	Min.	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*
Probable differences one section												
For one run, x_o	.....	1.80	1.80	1.80	.....	1.20	1.20	1.20	.....	0.60	0.60	0.60
For one stop, χ_o	.....	0.50	1.00	2.00	.....	0.50	1.00	2.00	.....	0.50	1.00	2.00
For total duration $\sqrt{x_o^2+\chi_o^2}$	.....	1.87	2.06	2.69	.....	1.30	1.56	2.34	.....	0.78	1.17	2.09
Time of occupation per section												
Minimum, $x+\chi$	50.00	50.00	50.00	50.00	34.00	34.00	34.00	34.00	18.00	18.00	18.00	18.00
Average, $x+\chi+4\sqrt{x_o^2+\chi_o^2}$	50.00	57.48	58.24	60.76	34.00	39.20	40.24	43.36	18.00	21.12	22.68	26.36
Graphic Time Total $x+\chi+8\sqrt{x_o^2+\chi_o^2}$	50.00	64.96	66.48	71.52	34.00	44.40	46.48	52.72	18.00	24.24	27.36	34.72
Time interval between two successive trains	100.00	129.92	132.96	143.04	68.00	88.80	92.96	105.44	36.00	48.46	54.72	69.44
No. of trains per day in each direction $\frac{24\times 60}{2(x+\chi+8\sqrt{x_o^2+\chi_o^2})}$	14.4	11.1	10.8	10.0	21.2	16.2	15.5	13.7	40.0	29.7	26.3	20.7
Utilization of the line, per cent	100.0	77.0	75.2	70.0	100.0	76.6	73.2	64.5	100.00	74.3	65.8	51.8

Case of 9-Section Line

	Min.	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*
Probable differences, $\sqrt{9(x_o^2+\chi_o^2)}$	.....	5.61	6.18	8.07	.....	3.90	4.68	7.02	.....	2.34	3.51	6.27
Time of occupation per section												
Minimum, $x+\chi$	50.00	50.00	50.00	50.00	34.00	34.00	34.00	34.00	18.00	18.00	18.00	18.00
Average, $x+\chi+4\sqrt{9(x_o^2+\chi_o^2)}$	50.00	72.44	74.72	82.28	34.00	49.60	52.72	62.08	18.00	27.36	32.04	43.08
Graphic Total, $x+\chi+8\sqrt{9(x_o^2+\chi_o^2)}$	50.00	94.88	99.44	114.56	34.00	65.20	71.44	90.16	18.00	36.72	46.08	69.16
Time interval between two successive trains	100.00	189.76	198.88	229.12	68.00	130.4	142.88	180.32	36.00	73.44	92.16	136.32
No. of trains per day in each direction $\frac{24\times 60}{2(x+\chi+8\sqrt{9(x_o^2+\chi_o^2)})}$	14.4	7.6	7.2	6.3	21.2	11.0	10.1	8.0	40.00	19.6	15.6	10.6
Utilization of the line, per cent	100.0	52.7	50.3	43.7	100.0	52.1	47.6	37.7	100.0	49.0	39.1	26.0

(b) That the minimum time for the train run of 12 Km. equal to 48 minutes (for a speed $V = 15$ Kms. an hour) to 32 minutes (for a speed $V = 22.5$ Kms. an hour) or to 16 minutes (for a speed of $V = 45$ Kms. an hour) with P.D. of 3.75 per cent that is:

1.8 minutes for $V = 15$ Km. an hour
1.2 minutes for $V = 22.5$ Km. an hour
0.6 minutes for $V = 45$ Km. an hour

In Table 1, there are first shown the component P.D.s for one section, the corresponding average time of occupation and the interval to be provided for in the graphic between succeeding trains to ensure "a stability of movement" in 99 cases out of a 100.

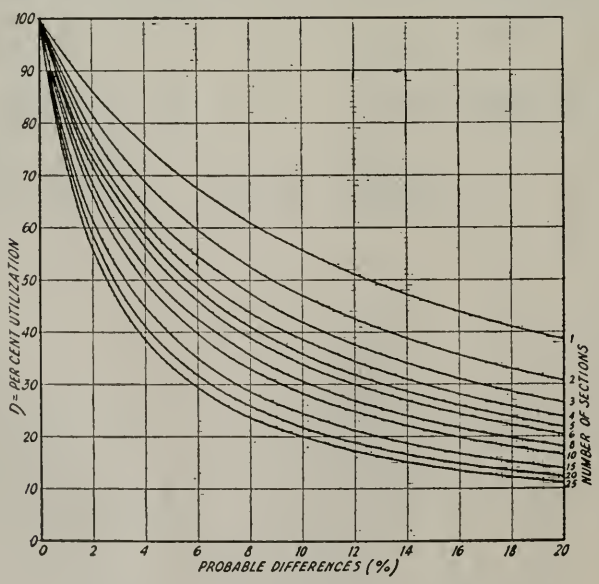
The same calculation is made for the line comprising 9 sections.

These examples show very clearly the considerable influence of irregularities in running times and in stops for maneuvers on the stability of train movement; the number of trains in each direction are thus reduced for these 9 sections:

from 14 to 7 or 6 for $V = 15$ Km. an hour
from 21 to 11 or 8 for $V = 22.5$ Km. an hour
from 40 to 19 or 10 for $V = 45$ Km. an hour

according to the values assumed for P.D.s for running and maneuvering.

It is also evident from this study that it is possible to trace a stable graphic for a number of trains at least twice as great for 45 Km. as for 15 Km. an hour.



$D = \frac{100}{1 + \beta \epsilon m}$

Fig. 6

Curves Showing the Theoretical Utilization of the Line Expressed as a Function of the Probable Difference and of the Number of Sections

The above concrete examples have, we believe, made the problem and its solution clearly intelligible. We can find a simpler and more general solution by expressing the elemental probable difference in per cent of the theoretical train runs.

Retaining the preceding notations, but expressing the component probable difference $\sqrt{x_0^2 + \chi_0^2}$ as a function of the theoretical duration of the trains run $\theta = x + \chi$, we can write:

$$\sqrt{x_0^2 + \chi_0^2} = \Sigma\,(x + \chi) = \Sigma\theta \text{ minutes.}$$

The preceding tables can then be presented as follows:

		Case Considered	
		Theoretical	*Practical*
Probable difference for one section	Running time	0	x
	Maneuvering	0	χ
	Total	0	$\sqrt{x_0^2 + \chi_0^2} = \Sigma\theta$
Duration of occupation of one section of a line composed of sect.	Minimum	$x + \chi = \theta$	$x + \chi = \theta$
	Average	θ	$\theta\,(1 + 4\,\Sigma\,\sqrt{n})$
	Graphic timetable	θ	$\theta\,(1 + 8\,\Sigma\,\sqrt{n})$
Time interval between 2 successive trains		2θ	$2\theta\,(1 + 8\,\Sigma\,\sqrt{n})$
Number of trains in each direction in 24 hours		$\dfrac{24 \times 60}{2\theta}$	$\dfrac{24 \times 60}{2\theta\,(1 + 8\,\Sigma\,\sqrt{n})}$
Per cent utilization of number of theoretical trains		100%	$\dfrac{100}{1 + 8\,\Sigma\,\sqrt{n})}$

The curves of Fig. 6 give the value of the utilization of a single track line as a function of the component probable difference $\Sigma\,\theta$ and of the number of sections.

Remarks

The present study shows that in the elaboration of graphic train movements on a single track line it may be interesting in order to increase output:

(a) To take advantage of the higher speeds of electric traction to reduce the number of sidings and stops. A notable reduction of energy consumption will be obtained and a diminution of wheel wear due to reduce wheel slipping at stopping points.

For lines of special traffic, mining traffic, for example, where trains circulate without breaking up in stations, it is of very great interest to diminish the number of stops and of maneuvers not only to reduce the theoretical time of occupation of the line but particularly for service.

A multiplicity of sidings is interesting because it permits, in case of troubles, a reduction of the duration of trouble. Sidings should be classified in two categories: sidings for normal operation and others for occasional use.

(b) To vary the time of stops proportionately to the distance from terminals or junction with a double track line whenever, of course, these terminal stations are arranged to insure the regular supply of trains to the line, outgoing and incoming. The duration of stops increasing from A to B for odd-numbered trains (direction A-B) and from B to A for even-numbered trains (direction B-A).

COMMENTS

By Committee on Economics of Railway Operation

The foregoing discussion by H. Parodi outlines an application of Gauss' Theory (better known as "The Theory of Probabilities") to the study of train performance. This application differs in many respects from the method described in the report of the Committee on Economics of Railway Operation (Proceedings of A.R.E.A., Vol. 23, pp. 738-745). On this account the Committee feels that it is desirable to comment on Parodi's method and compare his results with the results obtained by the A.R.E.A. method.

Fig. 7 following is a reconstruction on a larger scale of the actual train-hour diagram published in the A.R.E.A. Proceedings, Vol. 22, page 759, and shown as Fig. 4 in Parodi's discussion. The solid and dotted lines on this diagram are added to show the theoretical train-hour diagrams obtained by Parodi's and the A.R.E.A. methods respectively. Parodi's method for calculating the probability curve consists of a determination of various ordinates corresponding to equal increments of time (x_0) which he calls probable differences. For instance, he finds that according to the probability theory 50 per cent of the trains should make the run in less than the average time and consequently the other 50 per cent should make the run in more than the average time. In other words, the average time corresponds to 50 per cent of the trains.

The time corresponding to 75 per cent of the trains is, according to theory, equal to the average time less the probable difference x_0 and the time corresponding to 25 per cent of the trains is equal to the average time plus the probable difference x_0. If Y represents the percentage of trains and X the average time, the following table can be used for calculating other points on the curve.

When $Y = 99.62$	the corresponding time is	$X - 4x_0$
97.80	the corresponding time is	$X - 3x_0$
91.10	the corresponding time is	$X - 2x_0$
75.00	the corresponding time is	$X - x_0$
50.00	the corresponding time is	X
25.00	the corresponding time is	$X + x_0$
8.90	the corresponding time is	$X + 2x_0$
2.20	the corresponding time is	$X + 3x_0$
.38	the corresponding time is	$X + 4x_0$

The probable difference x_0 can be found by selecting two points on the actual train hour diagram, one corresponding to 75 per cent of the total number of trains and the other corresponding to 25 per cent of the total number of trains. The difference in the corresponding times will be equal to $2x_0$

For example, in the case of the actual train-hour diagram, Fig. 7, for road time 75 per cent of $112 = 84$ trains and the time corresponding is 6.65 hours, likewise 25 per cent of $112 = 28$ trains, for which the corresponding time is 9.4 hours. The difference between 9.4 and 6.65 equals 2.75

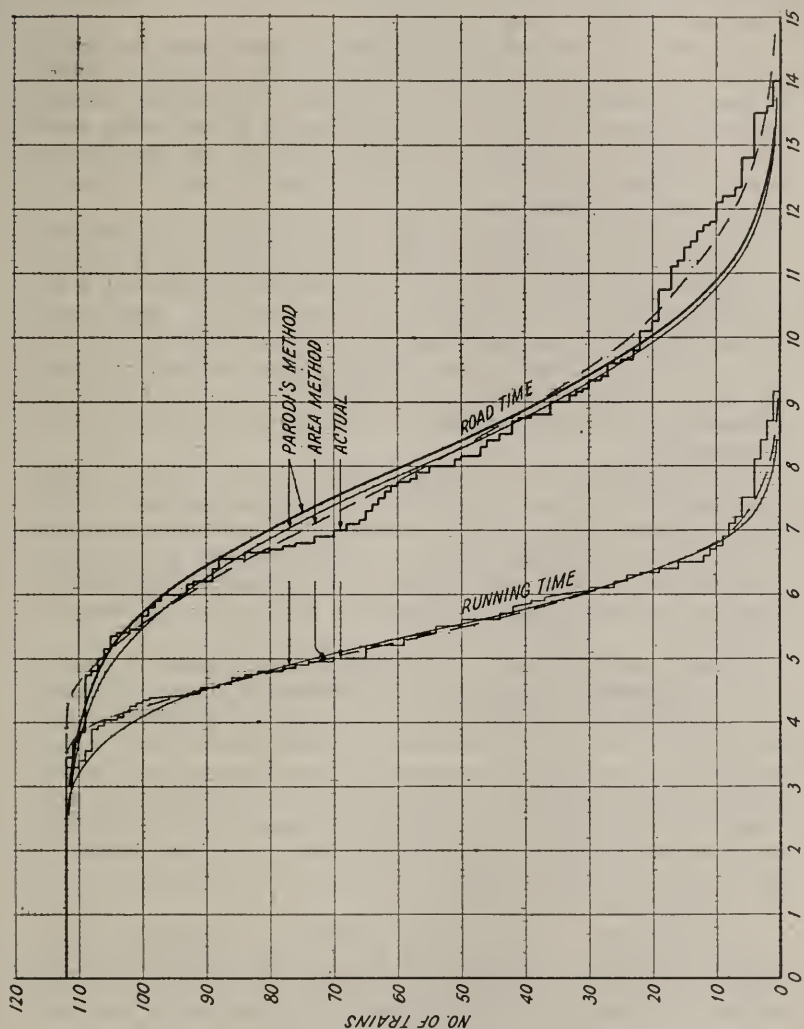

PAROD'S METHOD
AREA METHOD
ACTUAL
ROAD TIME
RUNNING TIME
HOURS
NO. OF TRAINS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
10
20
30
40
50
60
70
80
90
100
110
120

FIG. 7

hours, one-half of which is 1.375 hours $= x_0$. The mean of the two times (8.025) should be the average time from which the other points on the curve can be calculated, as shown in table above. This curve is represented by the light solid line in Fig. 7.

However, it is found that the average time of all the trains obtained by dividing the total train hours by the number of trains is 8.16 hours. When 8.16 hours is substituted for 8.025 hours the theoretical train-hour diagram shown by the heavy solid line is obtained and it is this curve which encloses the same area as the actual train-hour diagram. By adjusting the value of x_0 other probability curves which enclose the same area can be drawn through the center point.

The dotted curve is obtained by the A.R.E.A. method by selecting two points on the actual train-hour diagram, one corresponding to 80 per cent of the trains and the other to 20 per cent of the trains as described in the Committee's report referred to above. Apparently this curve approximates the actual train-hour curve more closely than the true probability curve of Gauss. The A.R.E.A. curve encloses a slightly larger area than the actual diagram, that is, the average time obtained is 8.23 hours instead of 8.16. If t_0 is adjusted .07 hours then the dotted curve will enclose the same area as the actual diagram.

In this connection, it is important to explain that the A.R.E.A. method is an attempt to fit an empirical equation to the statistical data represented by actual train-hour diagrams. The equation of the probability curve has been selected for this purpose because it apparently fits the facts, and is a simple equation which is easily derived. No attempt has been made to analyze the problem of train performance on the basis of the Theory of Probabilities.

Parodi on the other hand goes a step farther and discusses the problem from the standpoint of the Theory of Probabilities on the assumption that if the statistical data follows this law, then certain well-known relations exist which may be applied to the study of train performance. In his present discussion it is not clear how he proposes to make the application of the theory to practical problems, and for this reason no attempt has been made to apply Parodi's method to some of the problems where the A.R.E.A. method has been used. In general the application of the two methods is different because the same relations do not hold true in both cases, as will be seen from the following discussion.

As stated above, in order to apply the Theory of Probabilities to this problem it is necessary to assume that the upper and lower halves of the train-hour diagram are symmetrical. In other words, that half the trains make the run in less than the average time and the other half in more than the average time. This condition is not generally true in practice; more than half the total number of trains actually make the run in less than the average time, or vice versa, less than 50 per cent of the trains make the run in more than the average time. For example: In the case of the two diagrams shown in Fig. 7, the road time for 50 trains out of 112, or 44.6 per cent of the total number of trains, made the run in more than the average

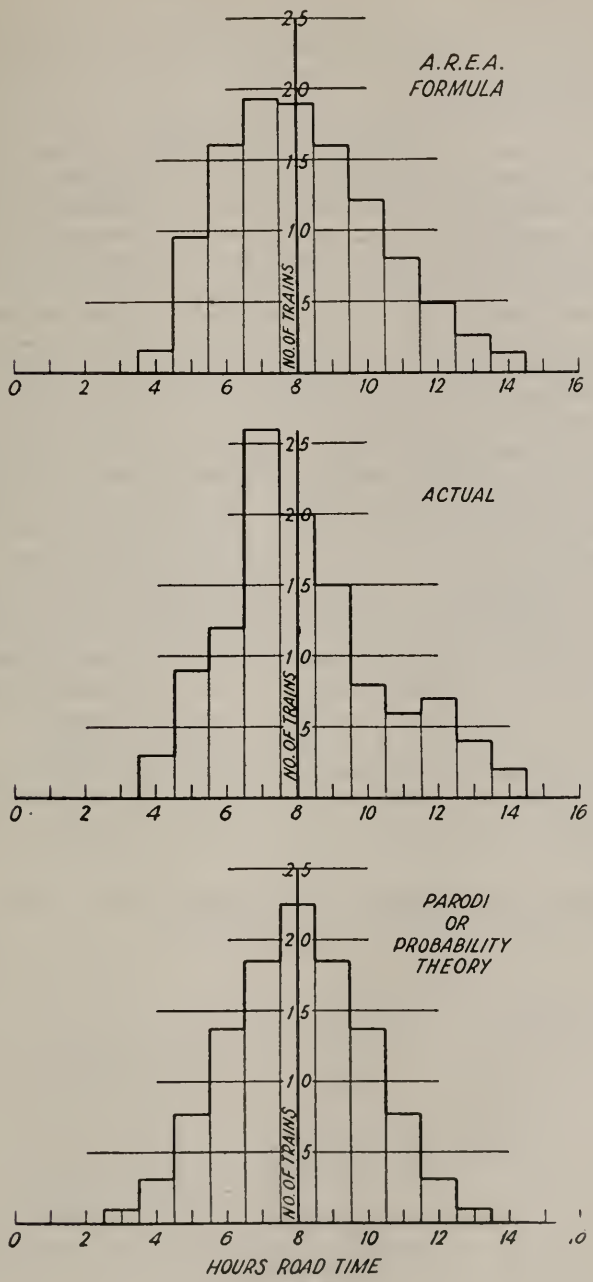

A.R.E.A.
FORMULA
ACTUAL
PARODI
OR
PROBABILITY
THEORY
NO. OF TRAINS
25
20
15
10
5
0
2
4
6
8
10
12
14
16
HOURS ROAD TIME

Fig. 8

road time of 8.16 hours and the running time of 54 trains out of 112, or 48.2 per cent of the total number of trains was more than the average running time of 5.46 hours.

A number of other diagrams have been checked in the same manner and in the majority of cases the percentages of trains making the run in more than the average time are below 50 per cent, which indicates that train operations do not strictly follow the "Theory of Probabilities."

In the case of the A.R.E.A. method it can be shown that 45.6 per cent of the total number of trains should make the run in more than the average time. Compare the percentage of trains making the run in more than the average time found by the A.R.E.A. method (45.6) with the actual 44.6 per cent and 48.2 per cent for road and running time, respectively, and with the percentage obtained by the Theory of Probabilities (50.0 per cent.)

In addition the A.R.E.A. method produces a curve which is only asymptotic to the horizontal axis. At the top of the diagram a definite time is obtained corresponding to 100 per cent of all the trains. This time in the majority of cases can be considered the minimum time and usually agrees closely with the actual minimum time. On the other hand, the Theory of Probabilities gives a curve which is asymptotic both top and bottom, consequently it does not give a true measure of the minimum time.

Fig. 8 is another way of plotting the statistical data in the form usually adopted for showing the distribution of observations or errors. It will be noted that the distribution diagrams obtained from the A.R.E.A. curve and the actual curve are displaced to the left of the Y axis, whereas the Probability diagram is symmetrical with the Y axis. The problem of displaced probability curves has been studied by a number of investigators, among whom are W. A. Shewhart, E. C. Molina and R. P. Crowell.*

The Committee feels indebted to Mr. Parodi for his interest in this problem and for his painstaking discussion of a very interesting theory, which holds promise of being a useful method for studying train performance.

*See Bell System Technical Journal, Vol. III, 1924, for further discussion of the Probability Theory and for references to other authorities.

A SIMPLIFIED COLUMN FORMULA OF THE SECANT TYPE

By J. B. Hunley, Engineer Bridges and Structures, Cleveland, Cincinnati, Chicago & St. Louis Railway

The column formulae most generally used seem to have been adopted, primarily, on account of their simplicity. This feature, combined with the fact that they fit with some accuracy the results of meager tests, is about all that can be said for them. They can apply only to the average column, as they contain no factors to compensate for variation in shape of the cross-section or eccentricities of loading.

It is generally admitted that the so-called "Secant" formula would give accurate values of the suitable working or ultimate stress for columns of any section, length or condition of loading, but in its original form it involves many "cut and try" operations, and consequently it is rarely used. This formula becomes of more practical use by expanding the secant term, and using only the first two terms of the series. In this form* the values obtained are on the safe side and reasonably accurate, but even with this modification it is yet too cumbersome to become popular.

A study of the effect of the various terms of the secant formula has suggested another form which is quite simple and yet retains to a remarkable degree all of the desirable features of the original formula.

The secant formula, for columns with pivoted ends, is generally expressed as:

$$P = \frac{f}{1 + \frac{ec}{r^2} \quad \text{Sec} \frac{L}{2} \sqrt{\frac{P}{EI}}} \qquad \text{(1)}$$

or,

$$p = \frac{f}{1 + \frac{ec}{r^2} \quad \text{Sec} \frac{L}{2r} \sqrt{\frac{p}{E}}} \qquad \text{(2)}$$

In this discussion the following nomenclature will be used:

A = Area of the cross-section of the column, in square inches.
P = Load in pounds, which the column will sustain without exceeding the unit stress f.
f = Maximum permissible unit stress.
$p = \frac{P}{A}$ = Average unit stress over the column section.
I = Moment of inertia of the column section.
r = Radius of gyration.
L = Length of column in inches.

*See A.S.C.E. Transactions Vol. LXXX B-1, page 568.

$k = \frac{L}{r}$ = Slenderness ratio.

c = Distance, in inches, from the neutral axis to the extreme fiber.

h = Distance, in inches, between the centers of gravity of all the elements of the column section on either side of the neutral axis.

E = Modulus of elasticity; assumed as 29,000,000.

e = The eccentricity, in inches, of the application of the load, to the axis of column.

Unless otherwise stated, the value assumed for e is that suggested by E. H. Salmon in "Columns"; that is: For crookedness of fabrication and variation in material over the section, $\frac{L}{750} + \frac{h}{40}$, and for average eccentric application of the load, $\frac{L}{1000} + \frac{h}{40} + \frac{h}{160}$. The assumed total eccentricity e is the sum of the above or $\frac{2.333L}{1000} + \frac{9h}{160}$, or $.00233L + .05625h$.

The values of p about both axes have been computed by formula (2) for some 16 columns, having different sectional areas and of the various forms usually encountered. The maximum permissible stress f was first assumed as 20,000, the eccentricity e as $.00233L + .05625h$, with the slenderness ratio k ranging from 0 to 300. The sections and characteristics of the various columns are shown on sheet 1. On sheets 2 to 17, inclusive, are plotted the values of p, e, $\frac{e}{r}$, and $\text{Sec}\,\frac{k}{2}\sqrt{\frac{p}{E}}$, for each column. On sheet 1, the sections are so arranged that axis 2-2 is always the axis about which the computed value of p is the smaller, or the axis about which the column would be expected to fail. This might be called the "limiting axis," and it is always the axis about which $\frac{c}{r}$ is the greater.

The difficulty of applying the secant formula (2) arises from the fact that p occurs on both sides of the equation, and of a different power. It will be noted from the diagrams 2 to 17 that when $k = 0$, $\text{Sec}\,\frac{k}{2}\sqrt{\frac{p}{E}} = 1.0$, the secant of 0 degrees, being 1.00. As k increases, the secant increases rapidly in value, being larger for small values of $\frac{c}{r}$ and smaller for large values of $\frac{c}{r}$. For any value of k less than 200, the curve representing the secant term may be assumed to be a parabola or

$$\text{Sec}\,\frac{k}{2}\sqrt{\frac{p}{E}} = 1 + \frac{k^2}{x\,\frac{c}{r}} \qquad (3)$$

When $f = 20{,}000$ and $e = .00233L + .05625h$, the value of x in (3) becomes approximately 9000, or without appreciable error we may substitute in equation (2) for $\text{Sec}\,\frac{k}{2}\sqrt{\frac{p}{E}}$, the term $1 + \frac{k^2}{9000\frac{c}{r}}$ and it then becomes:

$$p = \frac{20{,}000}{1 + \frac{e}{r}\left(\frac{k^2}{9000} + \frac{c}{r}\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The values of p for each column about the limiting axis (2-2) have been computed by equation (4), and the results shown by the dotted line on sheets 2 to 17. It is to be noted that for columns having an average value of $\frac{c}{r}$, such as columns L and M (k less than 200), the difference in the value of p when computed by formulae (2) and (4) is negligible, while for sections having minimum and maximum values of $\frac{c}{r}$, as have Columns Q and O, the difference is greater, but within a few hundred pounds, so that equation (4) will give results sufficiently accurate for any column when k is less than 200. By including another power of k, such as k^4, in (4), it would fit the secant formula quite closely for any value of k up to 300, for sections having average values of $\frac{c}{r}$ and by using $\frac{c}{r}$ to another power, the equation would fit more closely for the extreme values of $\frac{c}{r}$, but such refinement is not necessary.

A certain similarity to the Rankine formula is seen in equation (4). The Rankine formula being $p = \frac{f}{1 + \frac{k^2}{y}}$, in which y is some constant which must represent the terms $\frac{e}{r}$, $\frac{c}{r}$, and $\frac{1}{x}$ in equation (3), all of which are variable, so that the Rankine formula, which of all formulae in common use, is the only one which can claim any kinship to theory, is suitable only for columns of one particular section about one axis, unless the term y is varied, as $\frac{e}{r}$, $\frac{c}{r}$, and f vary; and it is not so used. With a constant value of y, as generally assumed, its slight superiority over the strictly empirical straight line or parabolic formula does not justify the additional labor involved in its application, except for long columns not usually encountered in design.

One peculiarity of the secant formula is that p does not vary directly as f varies. That is, the value of p when f is assumed as 40,000 is not twice the value of p when f is assumed as 20,000, for corresponding slenderness ratios. This must be taken into account in the development of a column formula. While the elastic limit of the column material may be 36,000 or 40,000 lb., the useful limit in bridge work is about 26,000, as, when that limit is reached under increased loading, the structure is usually considered ready for renewal.

If the tension members of a structure were designed for a certain loading and a stress of 20,000 lb. per square inch, they would all become stressed to 26,000 lb., if the load were increased 1.3 times, while if the compression members were designed for the same load by formula (4), and the load were then increased 1.3 times, the unit stress in the compression members would considerably exceed 26,000 lb. per square inch.

Then to have a structure which would be stressed uniformly to 26,000 lb. in all of its members, under an increased load, we should, for the compression members, start with a formula in which f has a value of 26,000, and if it were desired to use a designing stress of 20,000 lb. per square inch, divide the values of p obtained by 1.3. The values of p, assuming $f = 26{,}000$ and $c = .00233L + .05625h$, were computed for all the columns, about the limiting axis (2-2), by formula (2), and the simplified formula, corresponding to equation (4), was found to be:

$$p = \frac{26{,}000}{1 + \frac{e}{r}\left(\frac{k^2}{6400} + \frac{c}{r}\right)} \quad \ldots\ldots\ldots\ldots (5)$$

If a basic designing stress of 20,000 were selected, the designing formula would be:

$$p = \frac{20{,}000}{1 + \frac{c}{r}\left(\frac{k^2}{6400} + \frac{c}{r}\right)} \quad \ldots\ldots\ldots\ldots (6)$$

This formula (6) would produce slightly heavier sections in the original design than would formula (4), but with an increase over the designing load of 30 per cent the structure would be uniformly stressed to 26,000 lb., while if formula (4) were used, the compression members would be stressed to 26,000 lb. per square inch before the tension members reached that limit.

On sheets 18, 19 and 20, curve A represents the values of p (axis 2-2) for columns — M $\left(\frac{c}{r} = 1.624\right)$, O $\left(\frac{c}{r} = 2.485\right)$, and Q $\left(\frac{c}{r} = 1.168\right)$ computed by equation (2), $f = 26{,}000$; curve B, those computed by equation (5); curve C by equation (4), and curve D by equation (6). Curve E represents the ordinates of curve C multiplied by 1.3, and the difference in ordinates of curves E and B represents the overstress in columns with a 30 per cent increase in load, when designed by formula (4) rather than formula (6).

On diagram 21 are plotted the values of p computed for all 16 columns, by formula (2)—$f = 26{,}000$. It is seen that for any value of k, p becomes smaller, as $\frac{c}{r}$ becomes larger. This is more clearly shown on diagram 22, where, for several values of k, the values of p are plotted for corresponding values of $\frac{c}{r}$. There is almost a straight line relation between p and $\frac{c}{r}$, and the value of $\frac{c}{r}$ has a marked effect on p, especially when k has a value between 20 and 80, the common range in column design. The variation in the value of $\frac{c}{r}$ between 1.50 and 2.50, affects the value of p as much as a variation in the value of k from 40 to 60, or 60 to 80. To ignore this important fact and to continue to use some formula based on the value of k only merely for the sake of "simplicity" or "ease of application," seems inexcusable.

The value of $\frac{c}{r}$ approaches 1.00 as a minimum, but can scarcely be less than 1.15, about both axes, as in Column Q, and its maximum value is probably about 2.50 as in Column O, axis 2-2. The economical section then (considering main material only) is that in which $\frac{c}{r}$ is a minimum about either axis. It has been generally assumed that if the column section were such that the radius of gyration were the same about either axis, a column of given length would have the same strength about either axis, but the application of the secant formula shows that this is not true, unless the value of $\frac{c}{r}$ is the same about both axes.

In Columns E and F, r is the same about either axis, but both sections are limited in their capacity by the larger $\frac{c}{r}$, about axis 2.2. Comparing Column A with B, or C with D, we find that while the areas are identical, and the radii gyration, as usually considered, are about equal, that the increased value of $\frac{c}{r}$, caused by turning the flanges out, reverses the limiting axis, and Columns B and D have a much smaller load-carrying capacity than Columns A and C. A comparison of the columns shown on sheet 1 brings out some interesting facts as to economical and desirable column sections.

When the eccentricity e is assumed as $.00233L + .05625h$, the value of e in inches varies greatly for the various columns, but it will be seen on diagram 21 that the value of $\frac{e}{r}$ is quite uniform, having a minimum value

of $.00233k + .078$ for Column P, and a maximum value of $.00233k + .110$ for Columns D and Q. This is due to fairly constant value in all columns of $\frac{h}{r}$; about axis 2-2, the extreme range being from 1.39 to 1.97. For the degree of eccentricity assumed thus far we could use without serious error, for $\frac{e}{r}$, in formulae (4), (5) or (6), a mean value of $.00233k + .1$, which would avoid the somewhat tedious computation of h. If such a constant value of $\frac{e}{r}$ is assumed, the values of p plotted on diagram 22 will fall directly on the k curves. The slight variation shown is due to the variation in the value of $\frac{h}{r}$ for the several columns.

All of the above discussion is based on an eccentricity expressed by $.00233L + .05625h$, and if the degree of eccentricity is changed, the constant in the denominator of equations (4), (5) and (6) will change. The writer confesses that he has no very definite idea as to just what eccentricity should be assumed. It seems that it should at least be a function of the length on account of crookedness, if not a function of the depth, to account for the variation in quality or section of material in either side of the column. Mr. Salmon's suggested value, above used, may be high, but it is on the safe side. A value of $\frac{L}{750}$ has been proposed, and this probably is the minimum value which should be considered. Some study of this matter is now in progress and it is hoped that before long rational values to assume for eccentricity will be known.

On diagram 23 are shown the values of p, for Column M (axis 2-2), using $f = 26{,}000$ and $e = \frac{L}{750} = .00133L$, computed from equation (2). The simplified formula corresponding to equation (5) becomes:

$$p = \frac{26{,}000}{1 + \frac{e}{r}\left(\frac{k^2}{3500} + \frac{e}{r}\right)} \quad \ldots\ldots\ldots\ldots (7)$$

in which $\frac{e}{r} = \frac{L}{750r} = .00133k$.

And for basic designing stress of 20,000, the designing formula becomes:

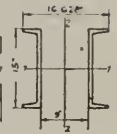
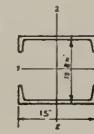
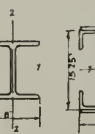
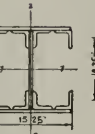
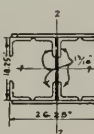
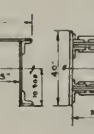
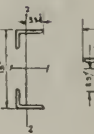
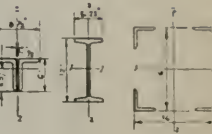
$$p = \frac{20{,}000}{1 + \frac{e}{r}\left(\frac{k^2}{3500} + \frac{e}{r}\right)} \quad \ldots\ldots\ldots\ldots (8)$$

All of the formulae herein presented are based on columns with pivoted ends as is now generally assumed in design, but the constant in the suggested formula can be determined to suit any end condition which may be considered proper. The form of the equation, however, will not change.

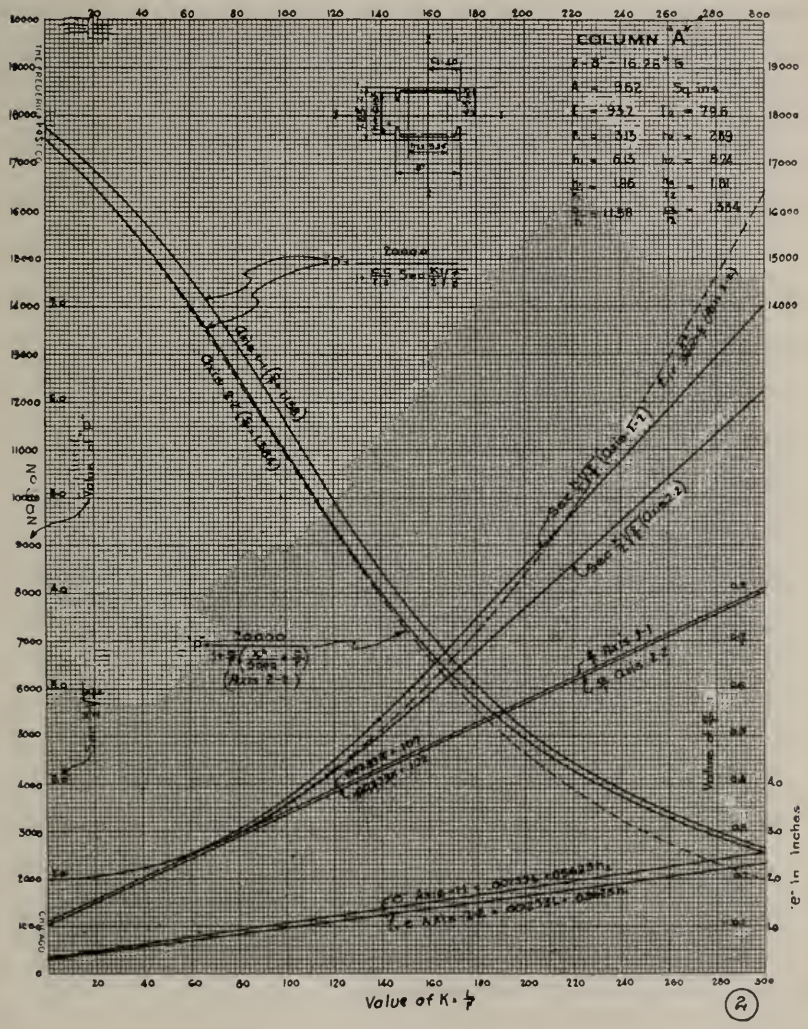
In the design of any column with the formula now in use it is necessary to determine r and k, and c is known as soon as the section is assumed or found. When the eccentricity is assumed as a function of the length only, $\frac{e}{r}$ in terms of k is known; if it is assumed to depend upon h, as well as the length, an average value of $\frac{e}{r}$, expressed in terms of k plus a constant, can be used without appreciable error, due to the quite uniform value of $\frac{h}{r}$ as pointed out in a preceding paragraph. The value of $\frac{k^2}{3500}$, $\frac{k^2}{6400}$ or whatever constant is used can be taken from a table or computed, just as we now do with the Rankine formula.

A few trial applications of the suggested formula will show that it is simple to use, and a comparison of the results obtained by it, with those from the ordinary empirical formula, for both designing and rating stresses, will bring out the importance of the additional factors which it contains. Its use will take a little more time, but it will be time well spent. Compression members are important members, and to attempt to design them without giving consideration to the important and varying characteristics of their sections is not consistent with the refinements applied to other features of design. The strictly empirical column formula should have been discarded long ago with other old "rule-of-thumb" methods.

For many helpful suggestions and laborious computations the writer is indebted to the following men in this office: Messrs. L. H. Schaeperklaus, A. M. Westenhoff, K. L. DeBlois and K. S. B. Nielsen.

COLUMN	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q
SECTION																
MAKE UP	Two- 8"-16.25# Channels	Two- 8"-16.25# Channels	Two- 15"-55# Channels	Two- 15"-55# Channels	Two- 15"-40# Channels	4-Pls-4"x4"x3/4" 2-Pls-24"x3/4"	14"-288.5# Beth H Col	8"-32# Beth-H Col.	Web-15"x3/8" 2-Pls-15"x7/8" 8-Ls-5 1/2"x5 1/2"x3/8"	Web-18"x9/16" 2-Pls 26"x13/16" 4-Ls-6"x6"x11/16" 4-Ls-6"x6"x13/16"	Cov. Pl. 25"x3/8" 2-Webs 18"x3/4" 2-Pls-4"x3/8" 4-2 1/2"x5 1/2"x7/8" Ls	Cov Pl. 40"x9/16" 4 Webs-36"x3/4" 4-Side Pls-19"x7/8" 4 " " - 35"x3/8" 8-Ls-6"x6"x7/8"	Two-Ls 5"x3 1/2"x1/2"	Two Ls 6"x4"x5/8"	12"-40.8# I-Beam	4-Ls 4"x4"x11/16"
AREA in²	9.52	9.52	32.22	32.22	23.52	57.76	84.5	9.17	36.73	119.86	37.3	338.34	8.00	11.72	11.84	20.12
MOMENT OF INERTIA	I_1 = 93.2 I_2 = 79.6	I_1 = 79.6 I_2 = 92.8	I_1 = 93.1 I_2 = 858	I_1 = 858 I_2 = 93.65	I_1 = 69.5 I_2 = 69.5	I_1 = 432.1 I_2 = 432.1	I_1 = 3836.1 I_2 = 1226.7	I_1 = 105.7 I_2 = 35.8	I_1 = 1684.5 I_2 = 682.8	I_1 = 7981 I_2 = 7597	I_1 = 2024.8 I_2 = 224.5	I_1 = 57499 I_2 = 47959	I_1 = 355.5 I_2 = 20	I_1 = 42.2 I_2 = 34.25	I_1 = 268.9 I_2 = 15.8	I_1 = 945.6 I_2 = 945.6
RADIUS OF GYRATION	r_1 = 3.13 r_2 = 2.89	r_1 = 2.89 r_2 = 3.12	r_1 = 5.58 r_2 = 5.16	r_1 = 5.16 r_2 = 5.59	r_1 = 5.43 r_2 = 5.43	r_1 = 8.65 r_2 = 8.65	r_1 = 6.74 r_2 = 3.81	r_1 = 3.40 r_2 = 1.98	r_1 = 6.77 r_2 = 4.51	r_1 = 8.16 r_2 = 7.86	r_1 = 7.57 r_2 = 7.76	r_1 = 13.03 r_2 = 11.91	r_1 = 6.68 r_2 = 1.58	r_1 = 1.90 r_2 = 1.71	r_1 = 4.77 r_2 = 1.08	r_1 = 6.85 r_2 = 6.85
h	h_1 = 6.13 h_2 = 5.24	h_1 = 5.24 h_2 = 6.12	h_1 = 10.61 h_2 = 9.19	h_1 = 9.19 h_2 = 10.64	h_1 = 11.24 h_2 = 9.48	h_1 = 17.42 h_2 = 15.64	h_1 = 12.85 h_2 = 6.08	h_1 = 6.504 h_2 = 2.90	h_1 = 13.10 h_2 = 6.55	h_1 = 14.13 h_2 = 13.73	h_1 = 13.72 h_2 = 14.95	h_1 = 25.6 h_2 = 20.8	h_1 = 13.24 h_2 = 2.87	h_1 = 3.44 h_2 = 2.56	h_1 = 8.84 h_2 = 1.50	h_1 = 13.5 h_2 = 13.5
c	C_1 = .3625 C_2 = 4.00	C_1 = 4.00 C_2 = 4.935	C_1 = 6.125 C_2 = 7.50	C_1 = 7.50 C_2 = 8.51	C_1 = 6.40 C_2 = 7.50	C_1 = 9.70 C_2 = 12.125	C_1 = 8.4375 C_2 = 7.45	C_1 = 3.938 C_2 = 4.00	C_1 = 8.00 C_2 = 7.625	C_1 = 9.938 C_2 = 15.125	C_1 = 10.905 C_2 = 11.50	C_1 = 20.0 C_2 = 19.55	C_1 = .75 C_2 = 3.34	C_1 = 3.97 C_2 = 4.25	C_1 = 6.00 C_2 = 2.625	C_1 = 8.00 C_2 = 8.00
$\frac{h}{r}$	$\frac{h_1}{r_1}$ = 1.96 $\frac{h_2}{r_2}$ = 1.81	$\frac{h_1}{r_1}$ = 1.81 $\frac{h_2}{r_2}$ = 1.96	$\frac{h_1}{r_1}$ = 1.97 $\frac{h_2}{r_2}$ = 1.78	$\frac{h_1}{r_1}$ = 1.78 $\frac{h_2}{r_2}$ = 1.97	$\frac{h_1}{r_1}$ = 2.07 $\frac{h_2}{r_2}$ = 1.76	$\frac{h_1}{r_1}$ = 2.01 $\frac{h_2}{r_2}$ = 1.81	$\frac{h_1}{r_1}$ = 1.91 $\frac{h_2}{r_2}$ = 1.60	$\frac{h_1}{r_1}$ = 1.91 $\frac{h_2}{r_2}$ = 1.465	$\frac{h_1}{r_1}$ = 1.94 $\frac{h_2}{r_2}$ = 1.52	$\frac{h_1}{r_1}$ = 1.73 $\frac{h_2}{r_2}$ = 1.75	$\frac{h_1}{r_1}$ = 1.86 $\frac{h_2}{r_2}$ = 1.93	$\frac{h_1}{r_1}$ = 1.96 $\frac{h_2}{r_2}$ = 1.75	$\frac{h_1}{r_1}$ = 1.98 $\frac{h_2}{r_2}$ = 1.82	$\frac{h_1}{r_1}$ = 1.81 $\frac{h_2}{r_2}$ = 1.49	$\frac{h_1}{r_1}$ = 1.85 $\frac{h_2}{r_2}$ = 1.59	$\frac{h_1}{r_1}$ = 1.97 $\frac{h_2}{r_2}$ = 1.97
$\frac{c}{r}$	$\frac{c_1}{r_1}$ = .1158 $\frac{c_2}{r_2}$ = 1.384	$\frac{c_1}{r_1}$ = 1.384 $\frac{c_2}{r_2}$ = 1.582	$\frac{c_1}{r_1}$ = 1.138 $\frac{c_2}{r_2}$ = 1.454	$\frac{c_1}{r_1}$ = 1.454 $\frac{c_2}{r_2}$ = 1.5425	$\frac{c_1}{r_1}$ = 1.178 $\frac{c_2}{r_2}$ = 1.381	$\frac{c_1}{r_1}$ = 1.121 $\frac{c_2}{r_2}$ = 1.416	$\frac{c_1}{r_1}$ = 1.252 $\frac{c_2}{r_2}$ = 1.955	$\frac{c_1}{r_1}$ = 1.158 $\frac{c_2}{r_2}$ = 2.020	$\frac{c_1}{r_1}$ = 1.180 $\frac{c_2}{r_2}$ = 1.770	$\frac{c_1}{r_1}$ = 1.2178 $\frac{c_2}{r_2}$ = 1.670	$\frac{c_1}{r_1}$ = 1.450 $\frac{c_2}{r_2}$ = 1.482	$\frac{c_1}{r_1}$ = 1.535 $\frac{c_2}{r_2}$ = 1.624	$\frac{c_1}{r_1}$ = 1.123 $\frac{c_2}{r_2}$ = 2.114	$\frac{c_1}{r_1}$ = 2.090 $\frac{c_2}{r_2}$ = 2.485	$\frac{c_1}{r_1}$ = 1.258 $\frac{c_2}{r_2}$ = 2.450	$\frac{c_1}{r_1}$ = 1.166 $\frac{c_2}{r_2}$ = 1.166

Sheet (1



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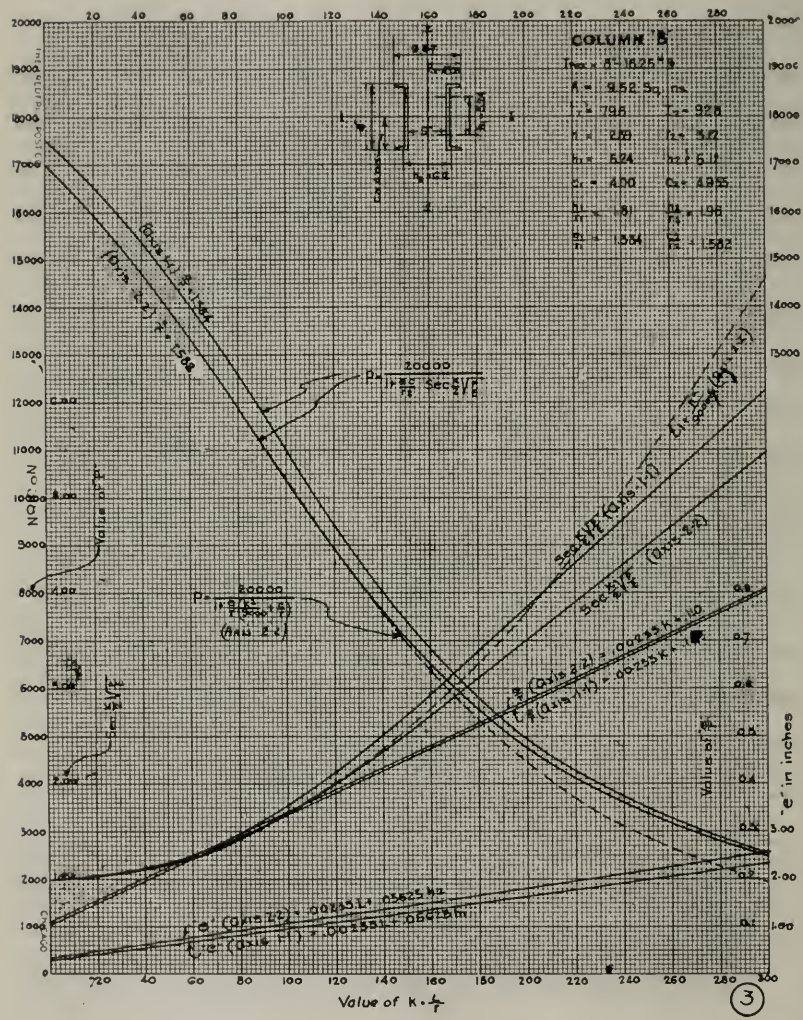
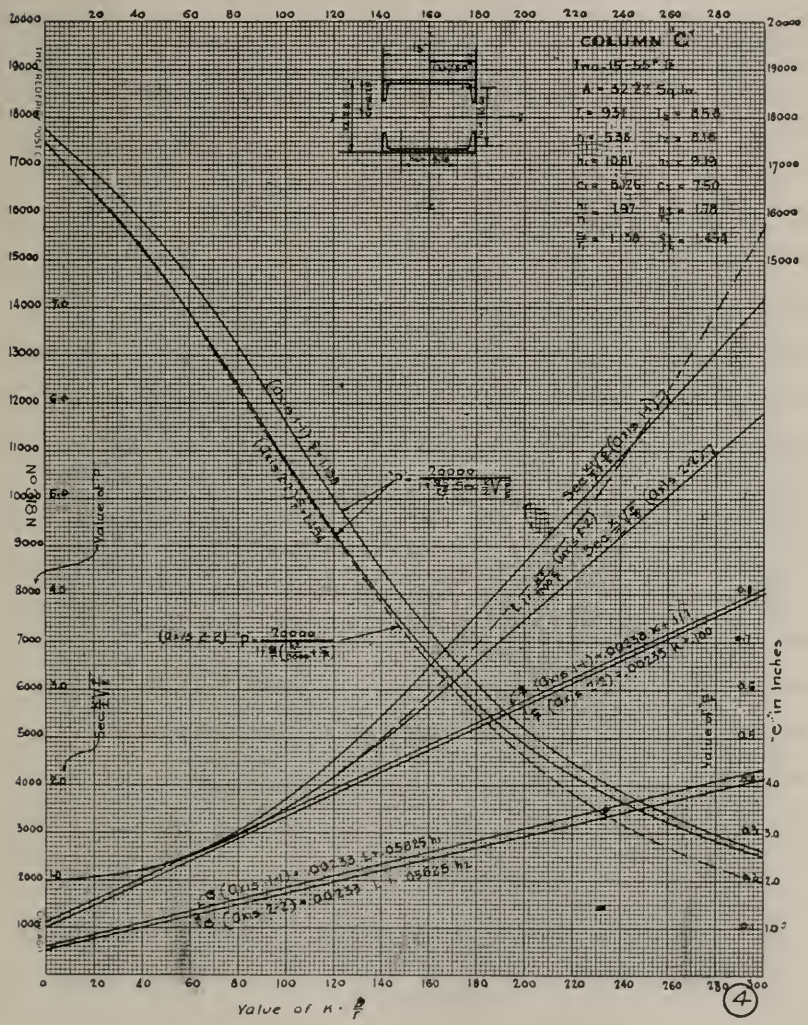
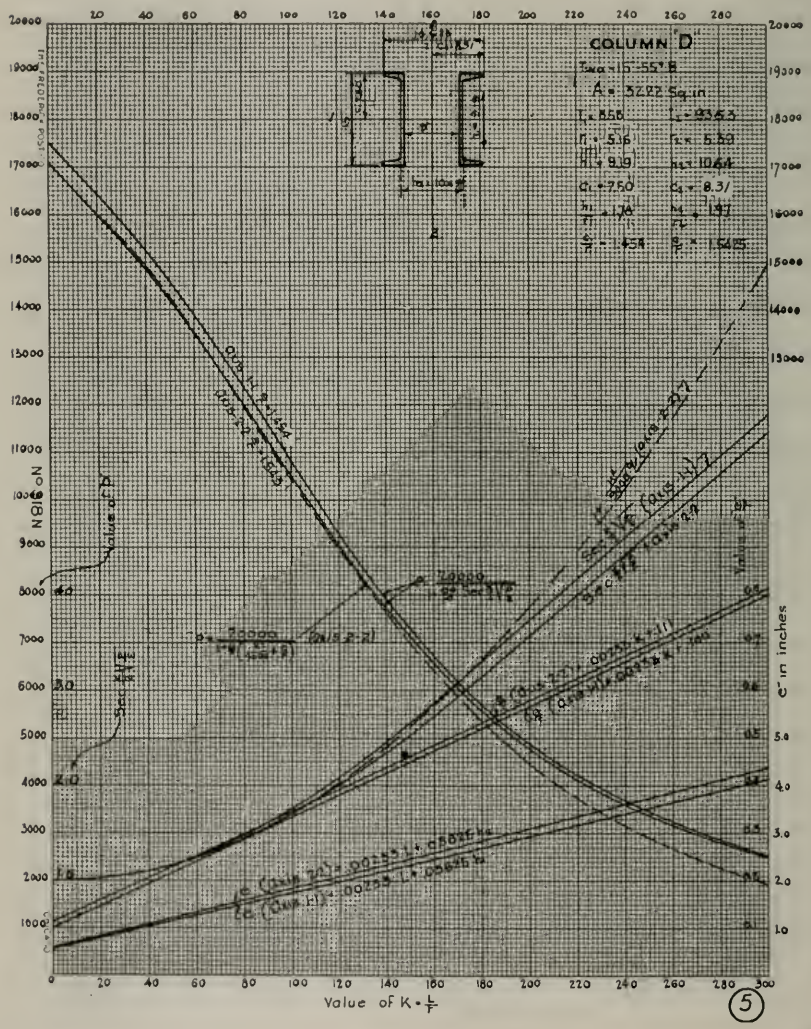
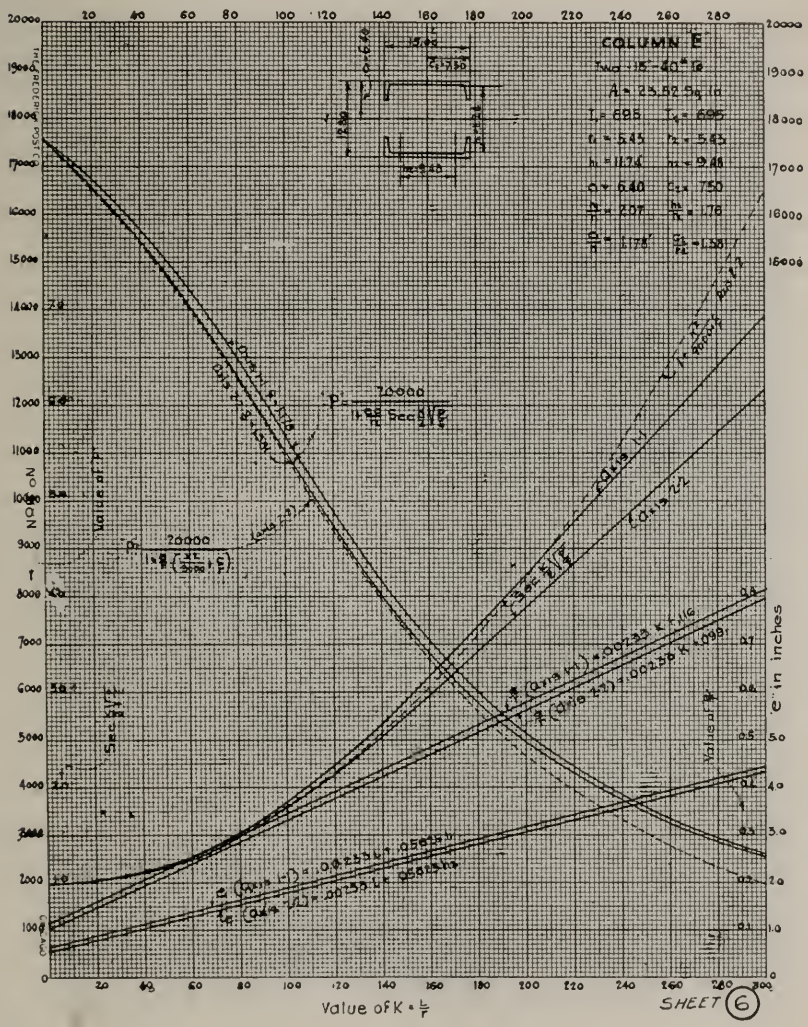
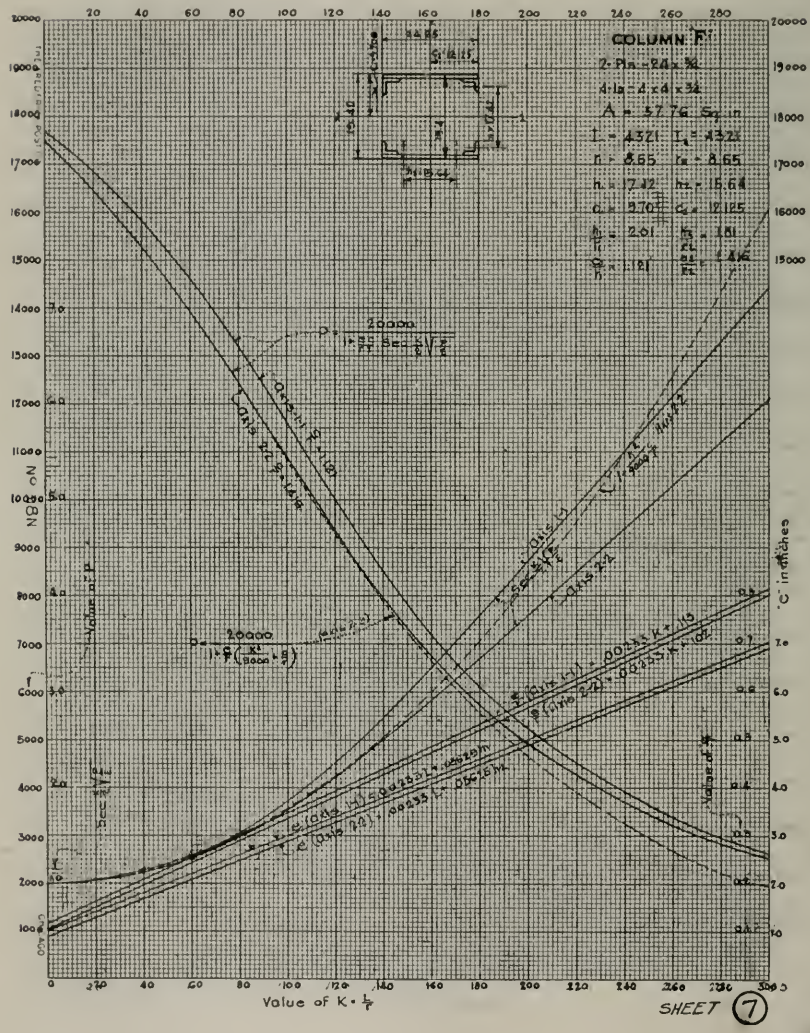

COLUMN "B"
Value of K = L/r
"e" in inches
Value of "P"
Value of "S"
Value of "e"
(Axis 2-2)
(Axis 1-1)
(Axis 2-2) = .00235 L + .05625 ha
(Axis 1-1) = .00235 L + .05625 ha
3

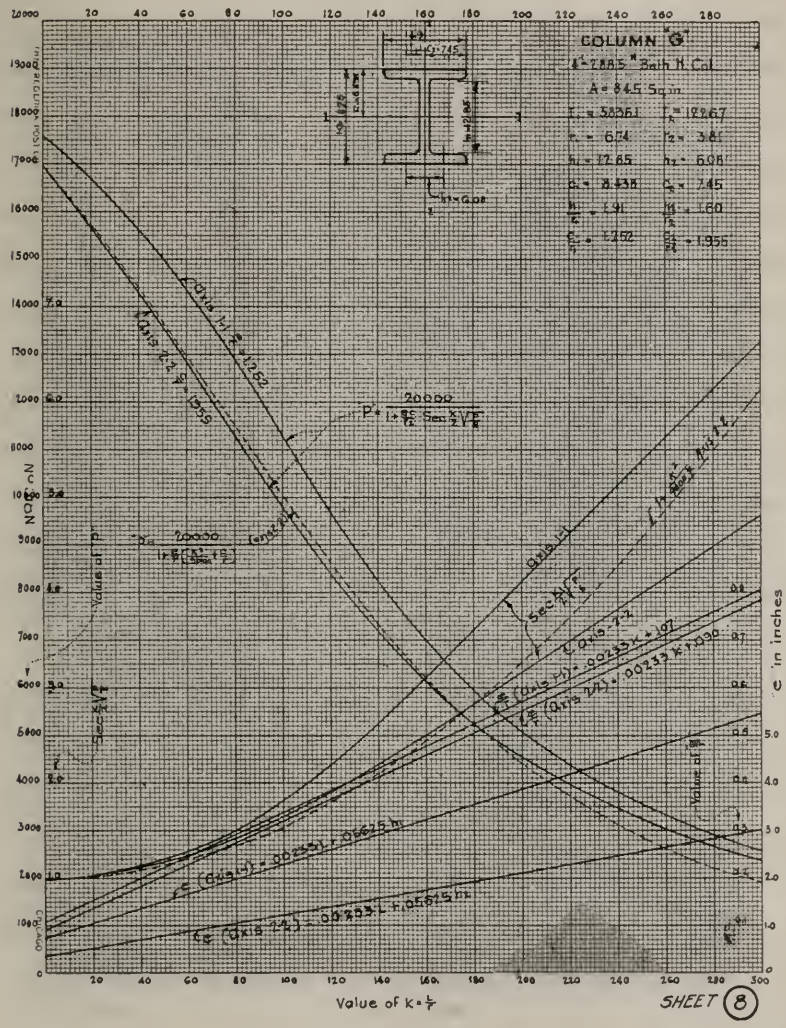


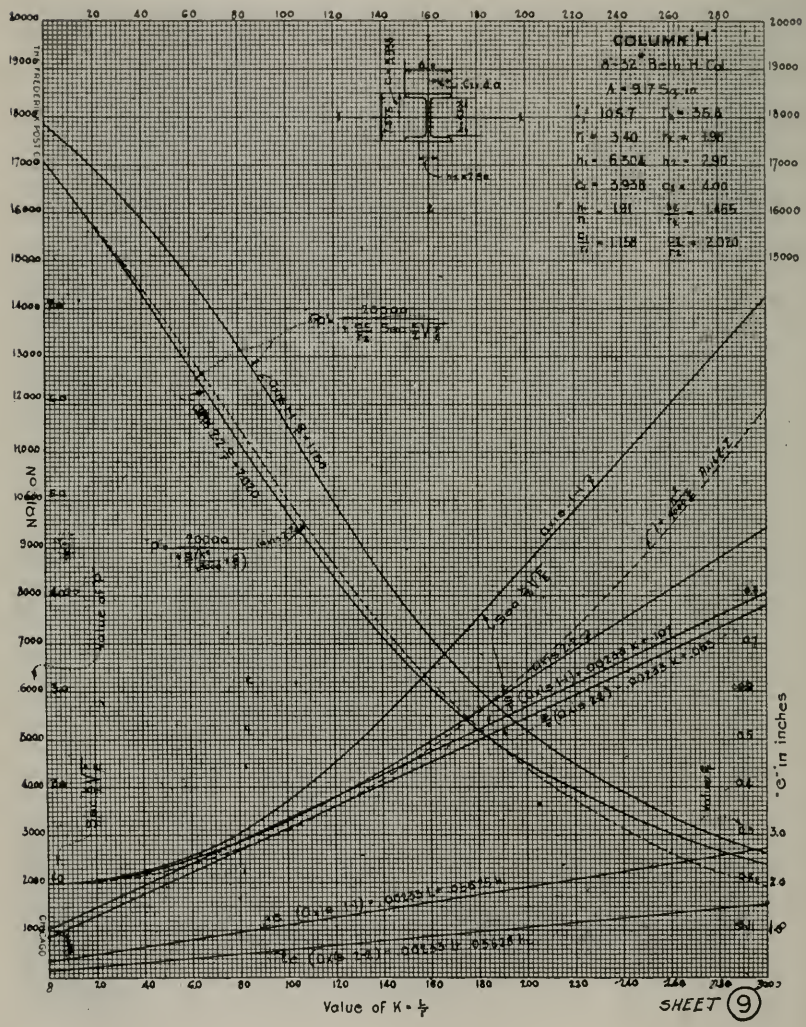
4

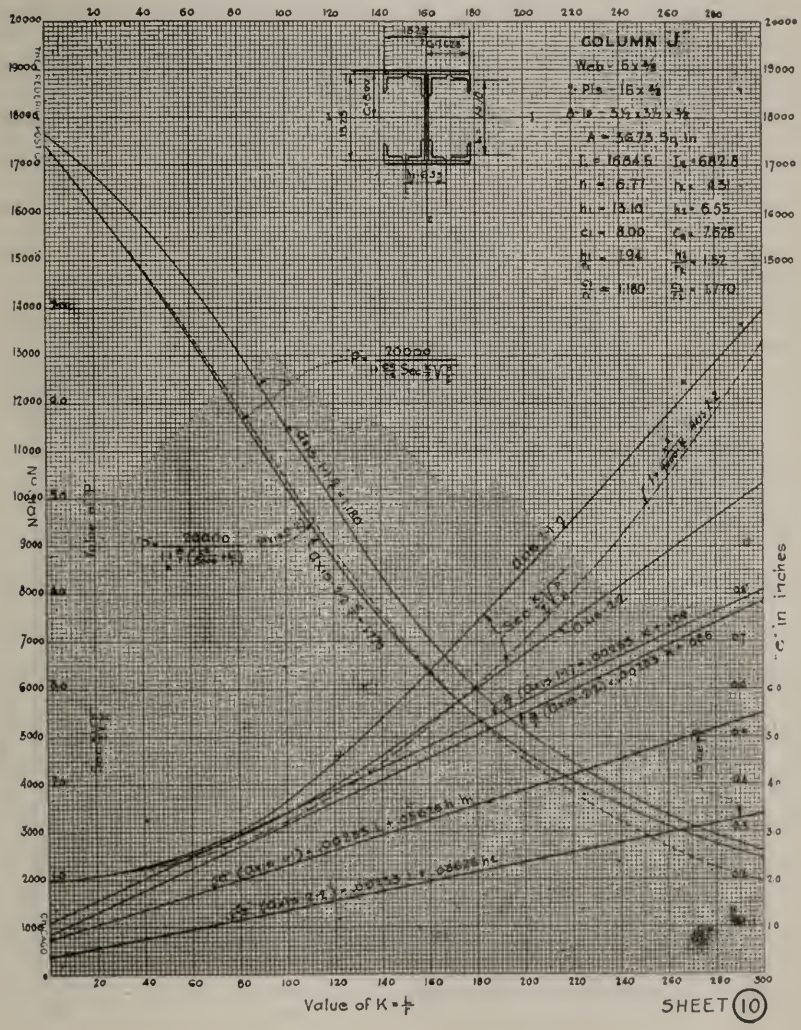

COLUMN "D"
A = 32.22 Sq. in.
Value of K = L/r
e in inches
Value of P
Value of e
No. 18N
5

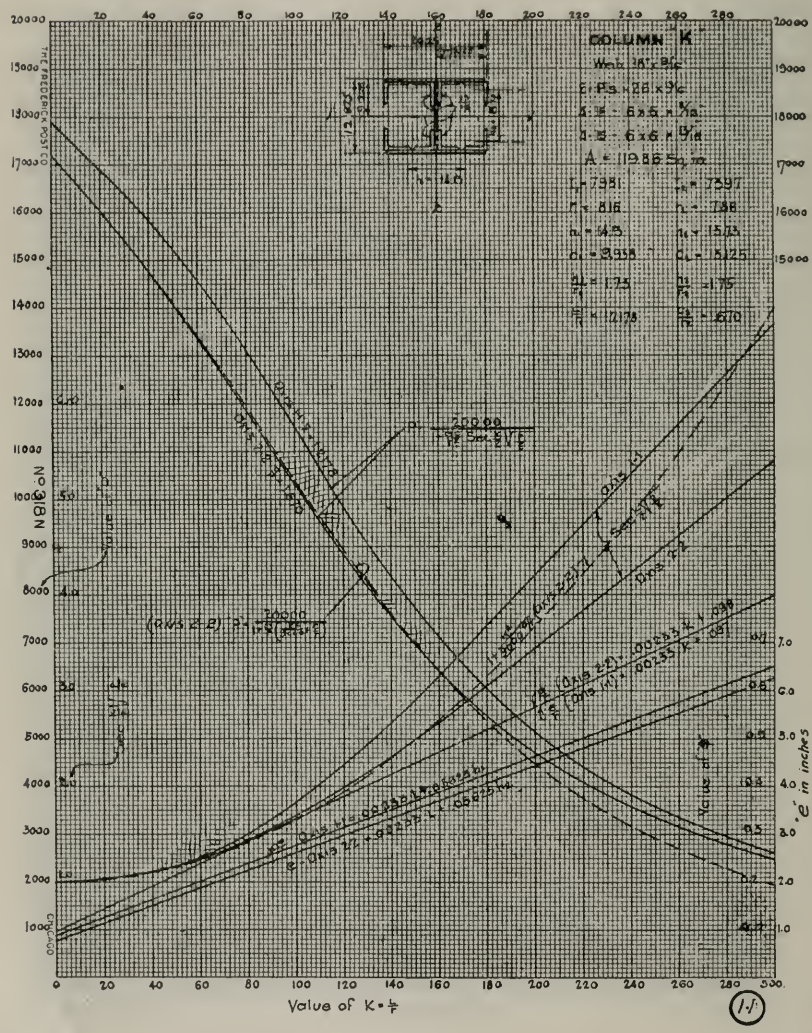

COLUMN E
Value of K = L/r
SHEET 6

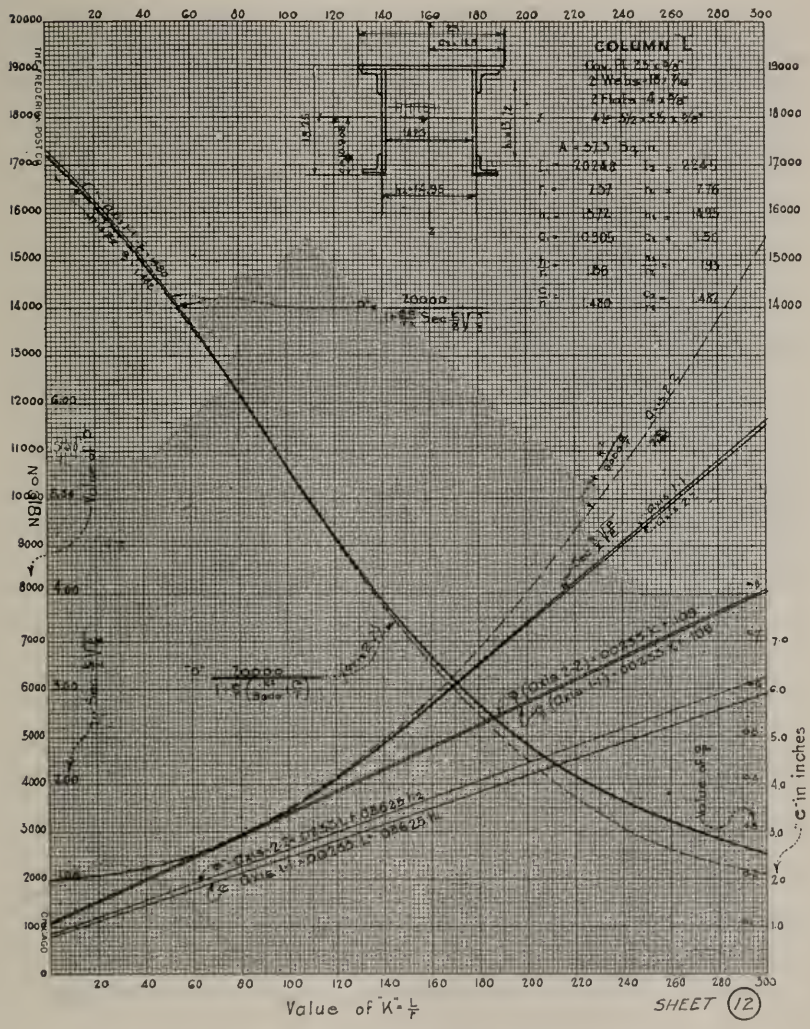

COLUMN "F"
2-Pls - 24 x 3/4
4-Ls - 4 x 4 x 3/4
A = 37.76 Sq. in
I = 4321
r = 8.65
h = 17.42
c = 9.70
h1/r1 = 2.01
c1/h = 1.21
I1 = 4321
r2 = 8.65
h2 = 15.64
c2 = 12.125
h2/r2 = 1.81
c2/h2 = 1.416
Value of P
Value of K = L/r
"C" in inches
SHEET 7

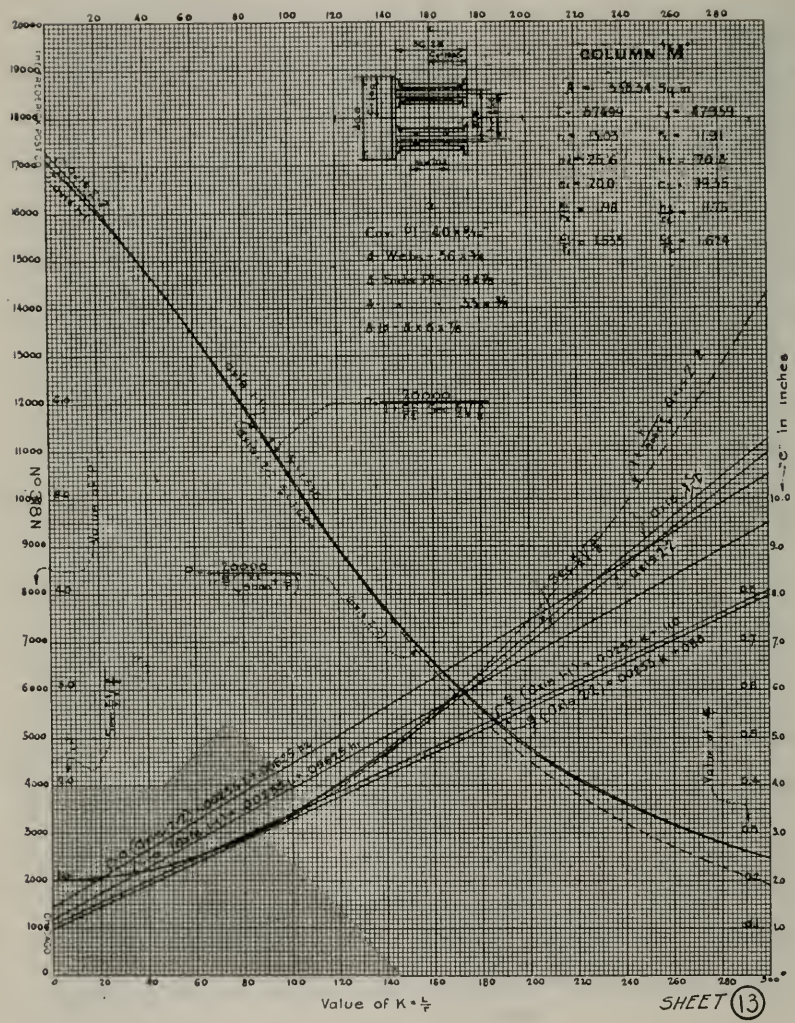

COLUMN G
Value of K = l/r
SHEET 8

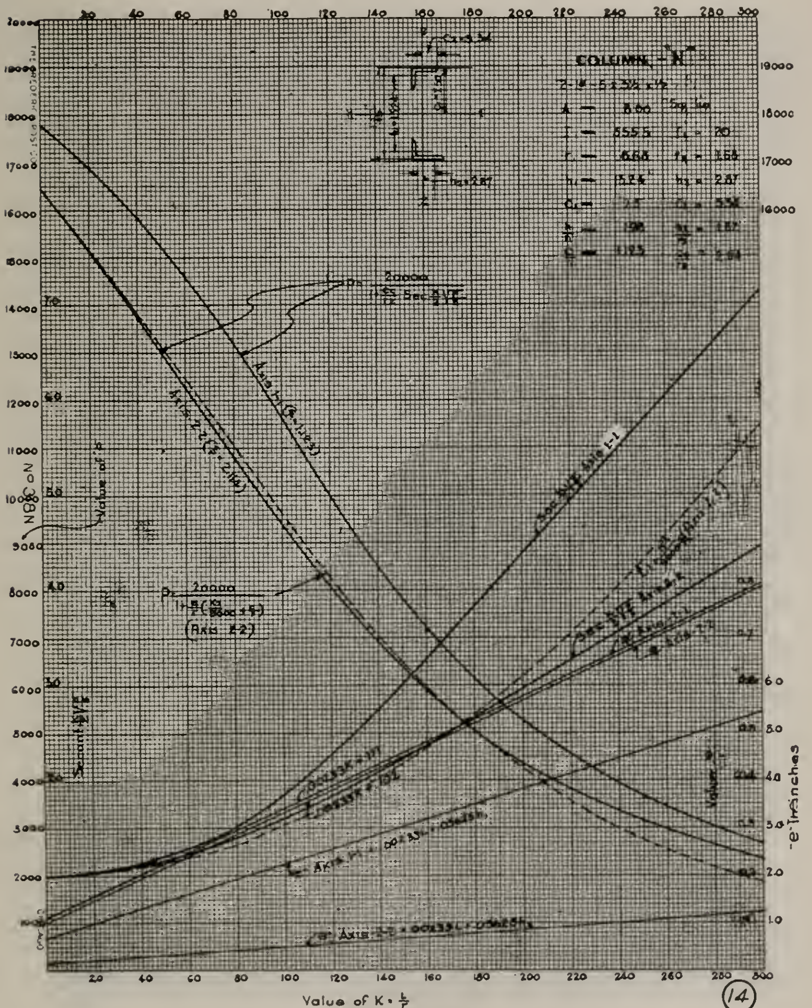

COLUMN H
8-32" Beth H Col
A = 9.17 Sq. in.
Value of K = L/r
"e" in inches
SHEET 9

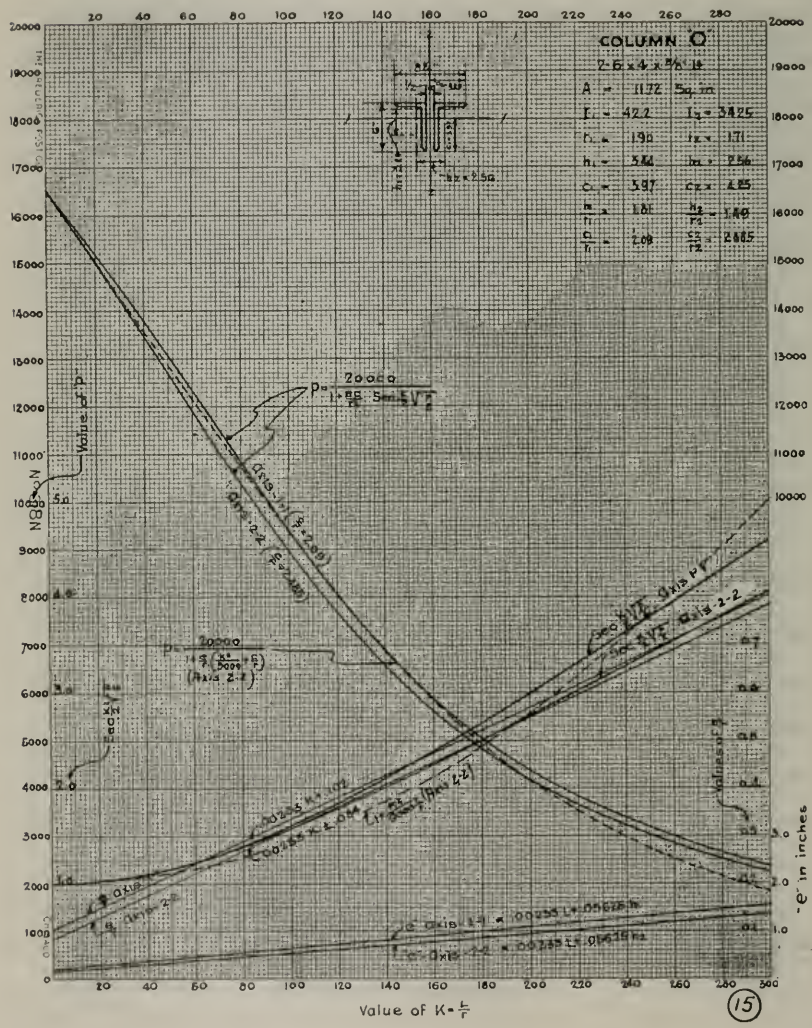

COLUMN "J"
Web - 16 x 3/8
2 Pls - 16 x 3/8
A - 3 1/2 x 3 1/2 x 3/8
A = 36.75 Sq in
I = 1684.5
I = 682.8
h = 6.77
h = 4.31
h = 13.10
h = 6.55
c = 8.00
c = 7.625
h1/r1 = 1.94
h2/r2 = 1.52
c1/r1 = 1.180
c2/r2 = 1.770
Value of K = l/r
"c" in inches
SHEET 10

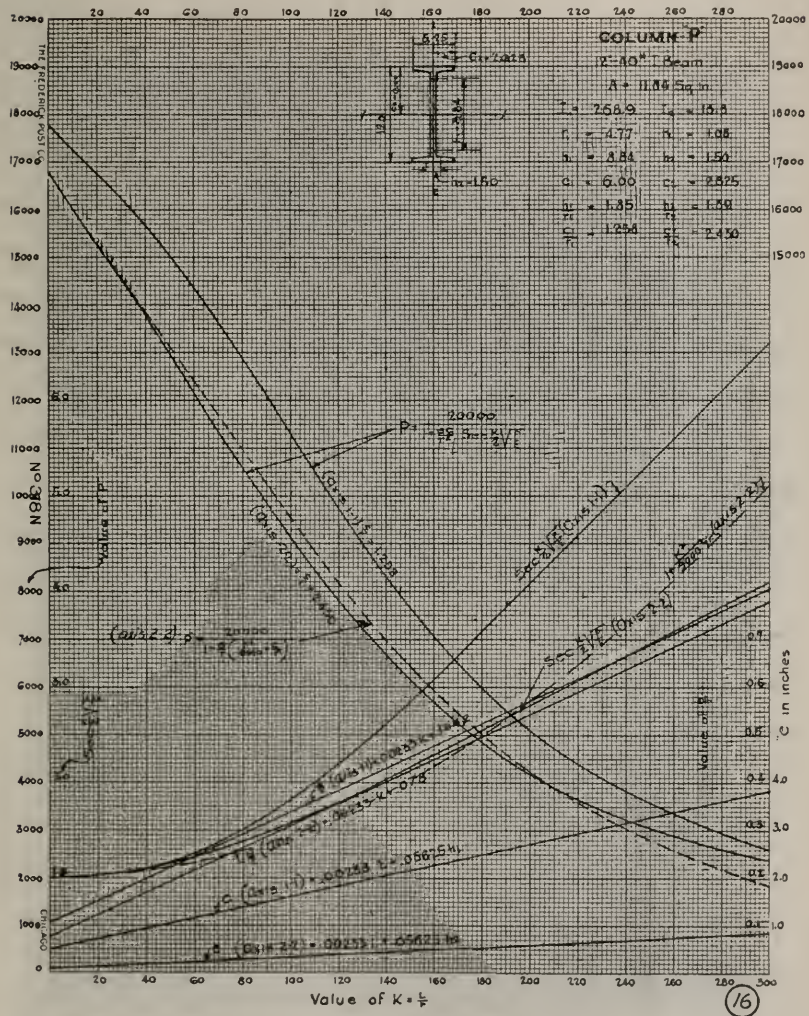

COLUMN K
Value of K = L/r
"e" in inches
No. 318N
THE FREDERICK POST CO.
CHICAGO

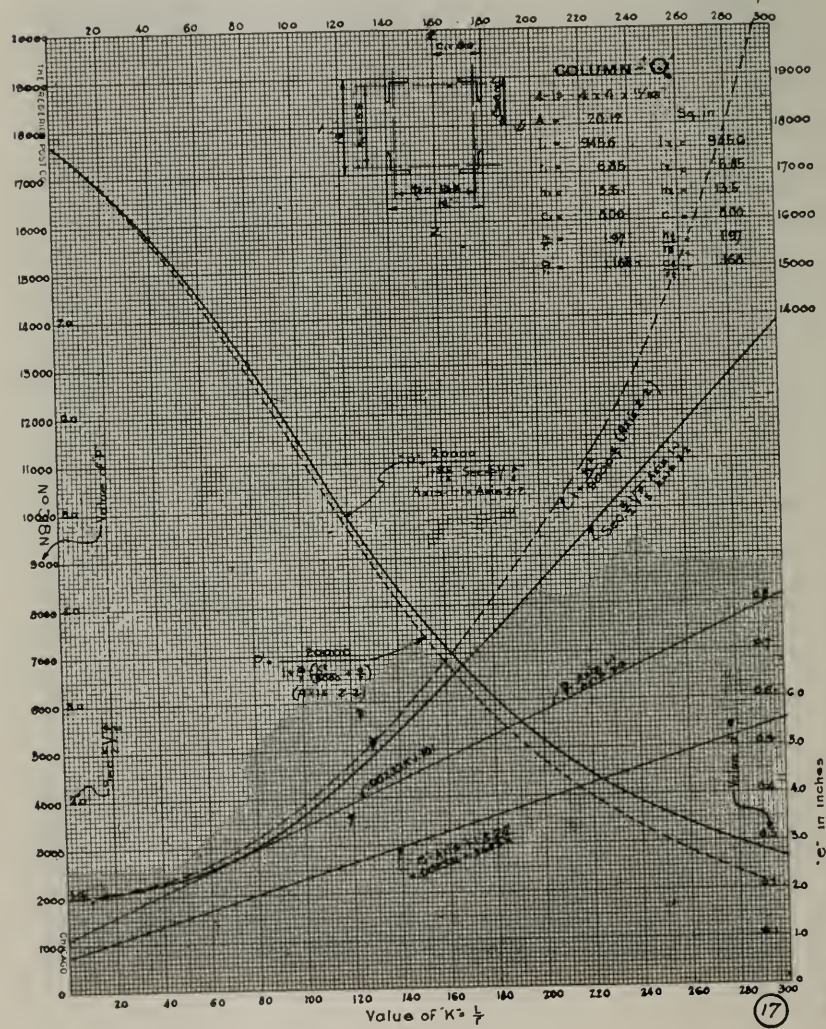

COLUMN L
Value of "K" = L/r
c in inches
SHEET 12


COLUMN "M"
Value of K = L/r
SHEET 13

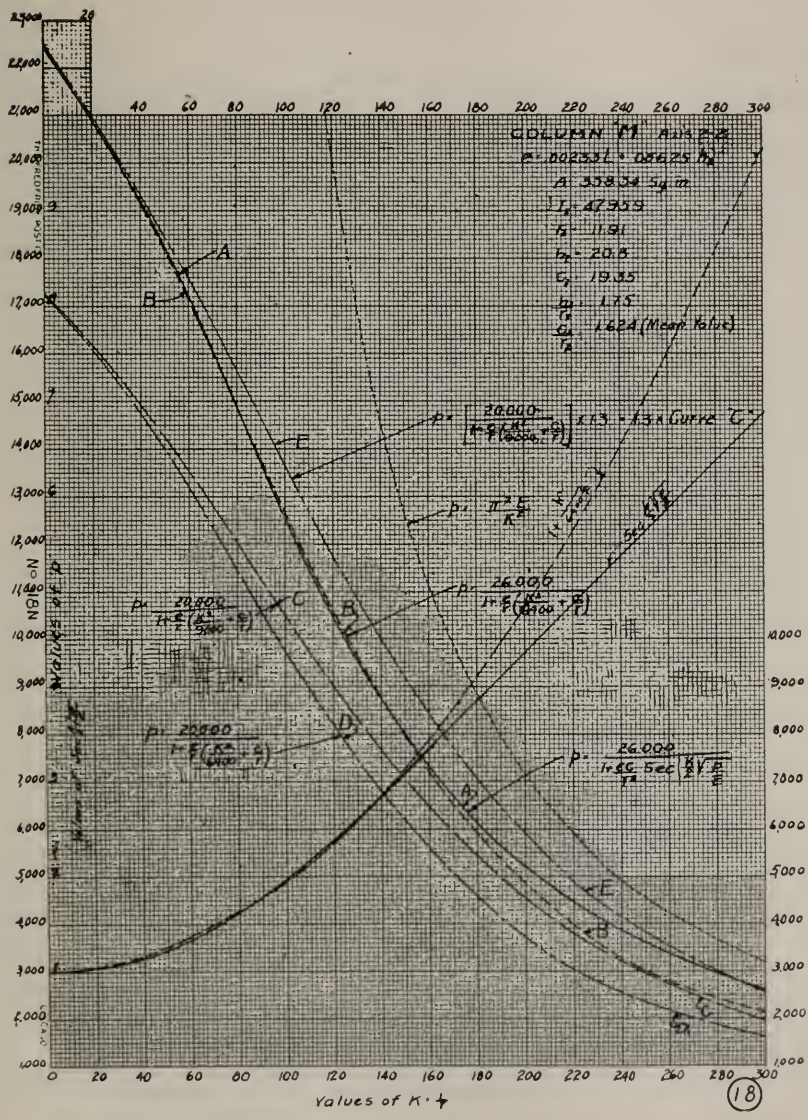

COLUMN "K"
Value of K = L/r
-e- Inches
14


COLUMN "O"
2-6 x 4 x 3/8 Lg
A = 11.72 Sq. in
I1 = 42.2 I2 = 3.425
r1 = 1.90 r2 = 1.71
h1 = 3.44 h2 = 2.56
c1 = 5.97 c2 = 4.25
m/r1 = 1.81 h2/r2 = 1.49
c1/r1 = 2.09 c2/r2 = 2.485
Value of "P"
Value of K = L/r
"e" in inches
Axis 1-1
Axis 2-2
Axis P
Axis g
Axis e
Values of g
15

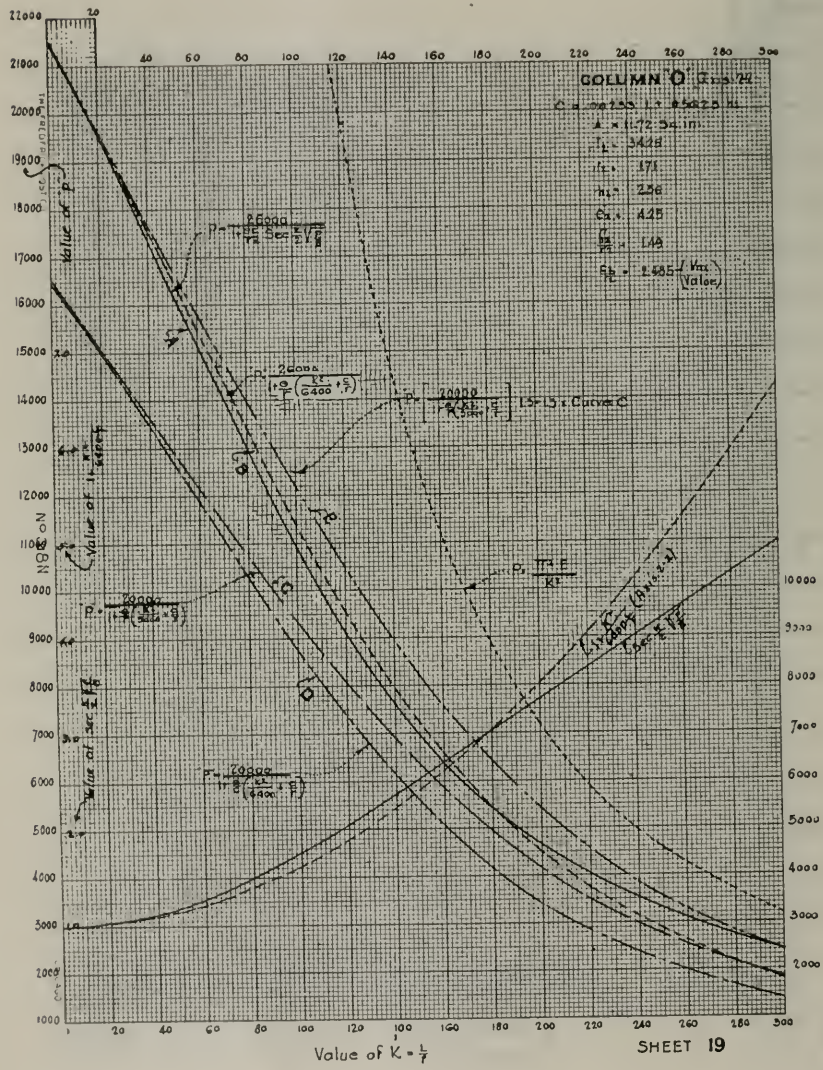

COLUMN P
12"-40# I Beam
A = 11.84 Sq. in.
Value of P
Value of K = L/r
C in inches
THE FREDERICK POST CO.
CHICAGO
16

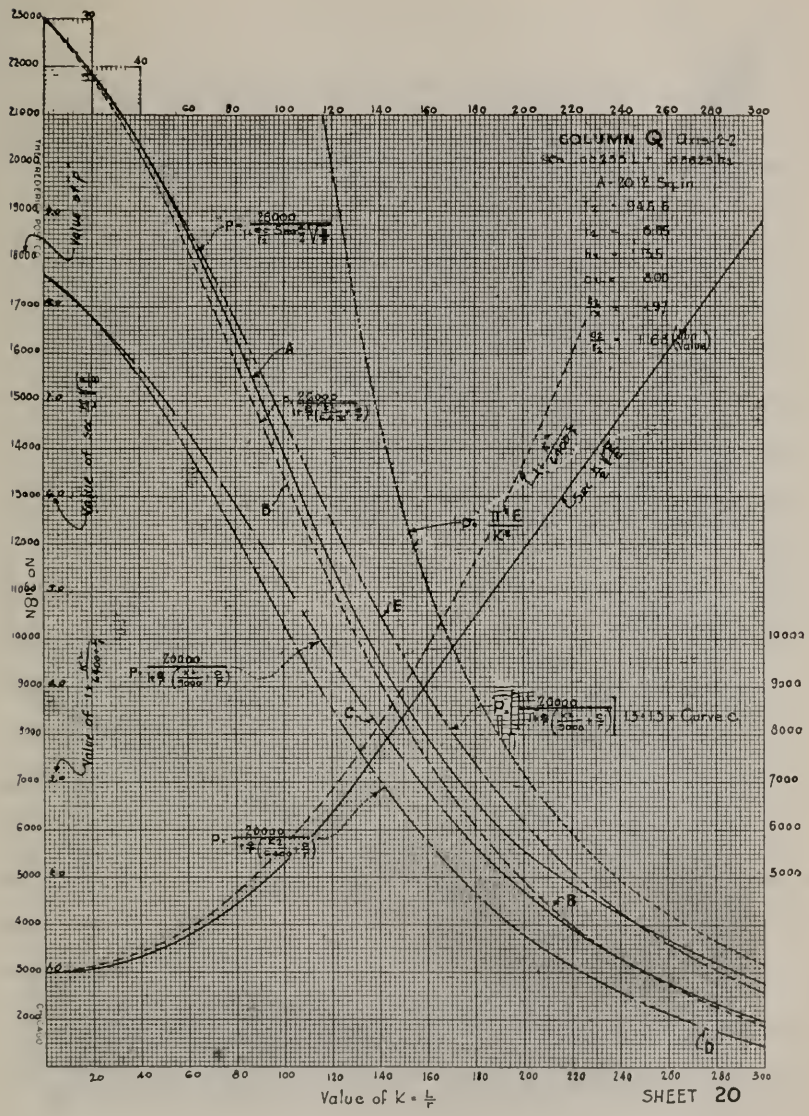


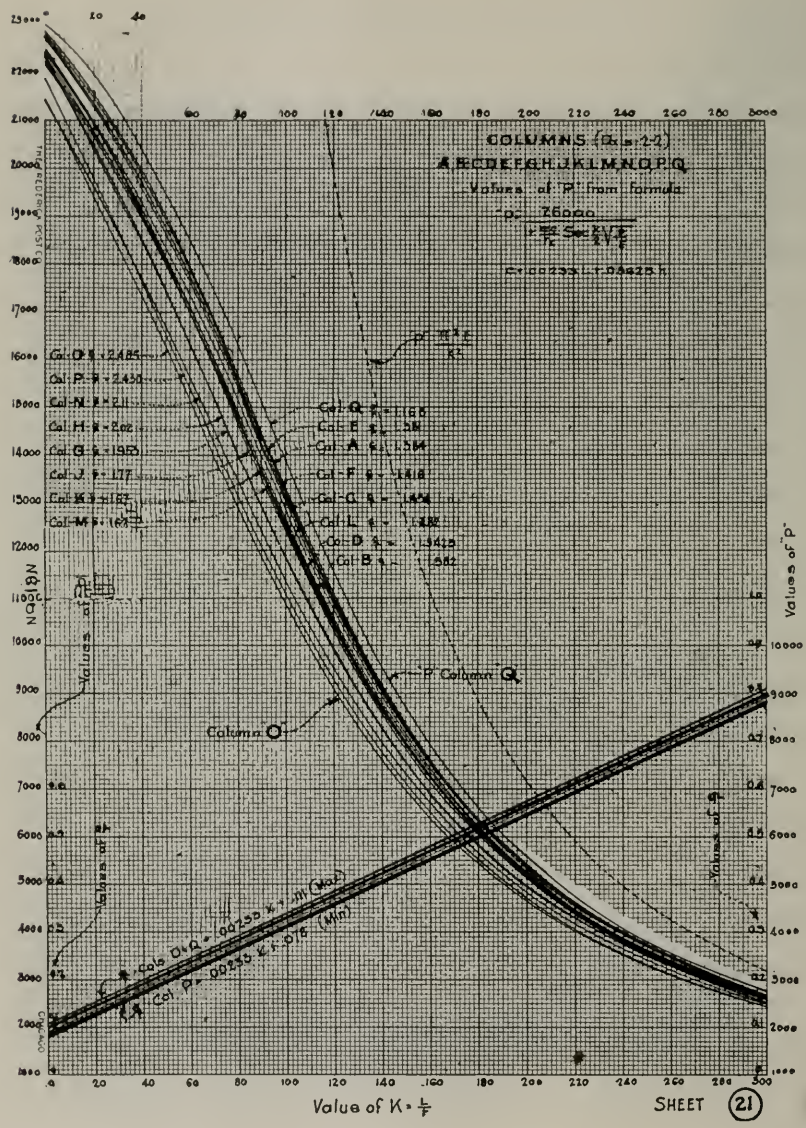
17

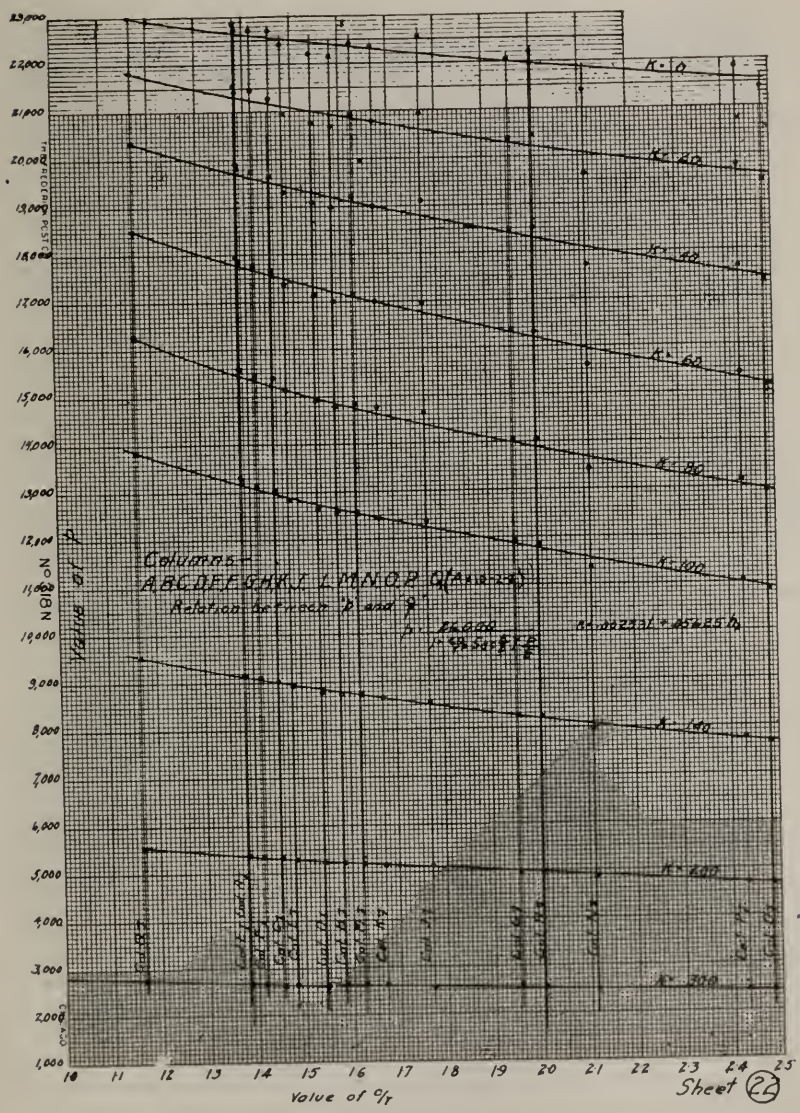


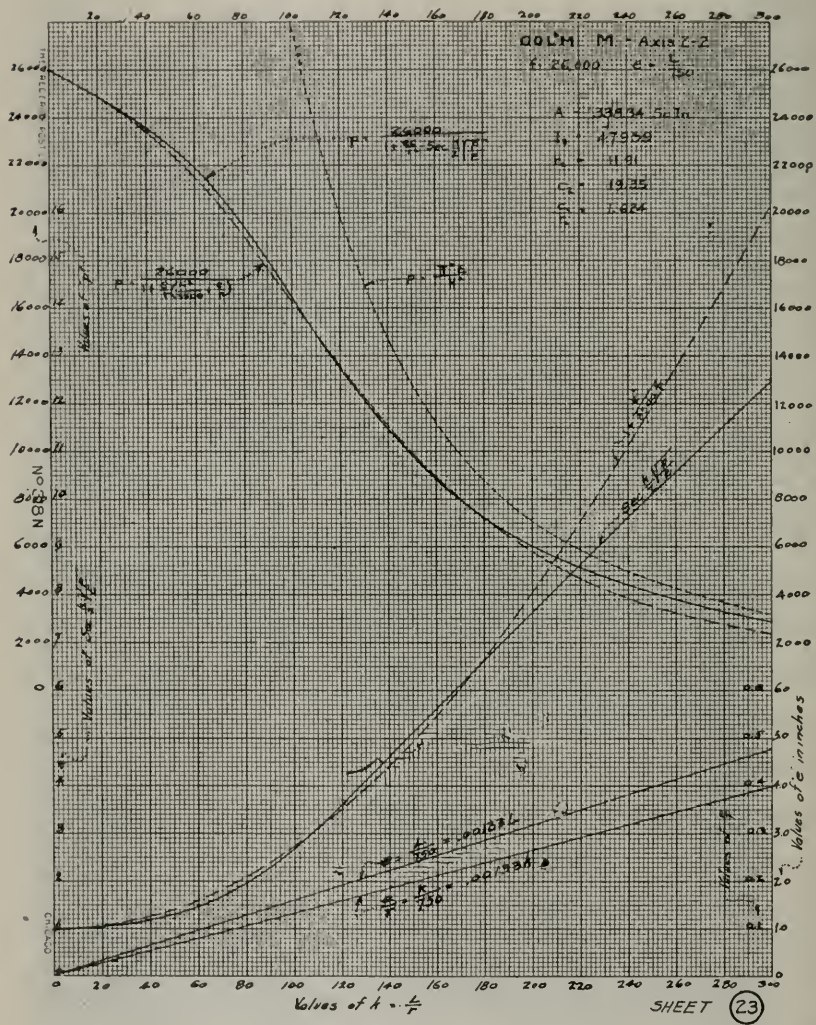
(18)


COLUMN O
Value of K = 1/r
SHEET 19


COLUMN Q
A = 20.12 Sq. in.
Value of K = L/r
SHEET 20


COLUMNS (Da = 2-2)
A B C D E F G H J K L M N O P Q
Values of "P" from formula
Col. O
Col. P
Col. N
Col. H
Col. G
Col. J
Col. K
Col. M
Col. Q
Col. E
Col. A
Col. F
Col. C
Col. L
Col. D
Col. B
"P" Column Q
Column O
Values of "P"
Value of K = L/r
SHEET 21


Columns—
A B C D E F G H K J L M N O P Q
Relation between 'p' and 'q'
Value of p
Value of q/r
K = 0
K = 20
K = 40
K = 60
K = 80
K = 100
K = 140
K = 200
K = 300
Sheet 22


Values of h = L/r
Values of e inches
SHEET 23

THE PURCHASE OF MATERIALS, TOOLS, APPLIANCES AND SUPPLIES

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This subject originates with the person who sets out to purchase an article of apparel, or a rather costly household utility. He may have to visit several stores if he desires to obtain the most satisfactory style or type at the least cost.

When these persons became connected with any of the engineering or purchasing departments of a corporation, they found it necessary to carry on a large part of this purchasing by mail, and, in order to do this intelligently, effectively, and with dispatch, a description, that is a specification, of the article desired was necessary. Moreover, if it was found to be satisfactory for the purpose, the orders could be repeated over and over again in routine duties, enabling him to handle a large amount of such business.

These specifications, however, must be kept in line with the advancing stages of the art, and must be precise in their requirements, and especially those of proof-testing. It would be disadvantageous to the manufacturer to be hampered in his own efforts for manufacturing economy by too many diverse specifications, and, recognizing this, these buyers and users have met together in technical societies for the purpose of unifying their specifications and practice; hence the American Railway Engineering Association, the American Society for Testing Materials, the United States Federal Specifications Board, etc.

This Association now has the Special Committee on Standardization to help it keep informed upon the advancing progress in this great effort at effective economy.

Some of these articles are extremely difficult to place upon the specification basis, especially those proprietary articles based on patent rights, but it is possible even in some of these cases to write such a specification as will place it on a competitive basis, and, as an illustration of what has been done by The Pennsylvania Railroad in a case of this kind, the "Specifications for Switch Lamps" is given herewith in complete detail. These dimensions of lamps which can be made the same are specified, especially, as in the case of lenses and oil cups, where they can be made interchangeable. The other most important part of the lamp is the burner and the ventilation, and, consequently, the proof-testing must be carefully and effectively provided for.

The "Instructions for Painting Structural Steel," also given, are the outcome of study dating back 30 years by reason of the large number of manufacturing establishments and the difficulty in selecting an undoubtedly reliable paint for use in protecting enormously costly steel structures so necessary on a railroad. The most careful safeguards must be placed around the protective coating purchase and application.

These thoughts concerning specifications have been continued below from notes previously prepared with especial reference to this subject of paint.

SPECIFICATIONS

With Particular Reference to Purchase and Use of Paint

Specifications are a description of the article, appliance, device or material desired, together with method of examination and proof-testing to ascertain if they comply with the requirements.

They are prepared in such form that they can be used in the regular routine of office work and avoid the necessity of dealing with each new request as though it were a new subject, thus clogging the working machinery and limiting the effectiveness and range of accomplishment of the daily task. When rightly prepared, they save time and dispose of a problem so that it will be dealt with without delay in a routine way through systematic prescription covering all the steps to be taken.

Specifications should be prepared so that:

(1) They will inform the Purchasing Agent of the kind and quality of the article required;
(2) They will instruct the Manufacturer upon the terms and conditions for furnishing the article by a precise statement of requirements, and define the methods of examination and proof-testing for checking the arrangement;
(3) They will inform the Inspector of the Purchaser of the conditions of purchase, manufacture, examination and proof-testing so that he will be the final authority for acceptance for the Purchaser:
(4) They will keep at hand conveniently for the ready reference of the engineers charged with the preparation of specifications, and of those who use the articles, appliances, devices or materials, a statement of the details of preparation in each case and a knowledge of the relationship between the chemical elements and physical characteristics involved in some of them, there being a multiplicity of articles required for construction and maintenance. Convenient information of this kind saves time in searching elsewhere.

It would be impossible for any busy officer to state clearly and preciously offhand the description of one of a hundred articles which he might need so as to enable a Purchasing Department to know with the minuteness necessary what he ought to get.

When it comes to the recommendation for the purchase of an article whose qualities are entirely unknown and whose economic value has never been proved, the responsibility of ordering officer is important.

To lessen the number of materials and articles in this category is an important work which is being carried on constantly.

One of the articles which has given a great deal of trouble in this particular is Paint. In order to obtain the large supply used on a rational and systematic basis, deep study has been accorded to it for many years. At the Altoona Laboratory the relative value of paint elements has been under observation and informative study for more than forty years, resulting in the preparation of specifications for paints for selected purposes. The Engineering Department has been engaged in a service study of recorded tests and observations for more than thirty years, the results of which have been embodied in:

"Instructions for Painting Steel, C.E. 31-(b)."

In addition, a record has been kept during that period of the economic service of paints of different manufacturers and trade names.

Very likely, the U. S. Government is the largest purchaser of supplies in the country, and it can be well understood how puny an effort it would be to attempt to decide upon the moment each time an article was necessary, the description and specific type. As would be expected, therefore, in any well-organized business of monumental proportions, the greatest work

in the preparation of specifications for unified purchase throughout the large number of departments and bureaus of the Government, and for the benefit of State administrations and others, is under way with the assistance of its scientific laboratories, than which there are none finer.

The Pennsylvania Railroad, too, is of monumental proportions, and the urgency for economy in transportation is so keen that advantage must be taken of the advances in methods of modern business. To that end, this great company has kept informed of the U. S. Government work, and has the advantage of its progress in providing specifications for its own.

Chemistry is not a secret art, but to extract knowledge requires indefatigable industry. This industry is the heritage and driving force of Government and railroad scientists, as of those engaged in the manufacturing industry. It is often the province of the latter in the keenness of industrial competition to wrap his product in terms of mystery which are confusing and time wasters to the large customer.

Good paint *can be* obtained on specifications drawn up by Government and railroad men, as well as by paint manufacturers, and, fortunately, but little specifications are needed for the most serviceable paint for structural steel—*red lead.*

But a most important part of specifications is proof-testing, and when that is neglected, poor material will be apt to creep in.

However, in the purchase of our structural steel and building paints under specifications, proof-testing is exacted by the Stores Department, and it is understood that paints sent out from the Storehouses have been so examined.

When this plan of proof-testing before using the product, has been well inaugurated in case of painting by contract in which the contractor furnishes the paint, it is believed that careful adherence to the instructions in C.E. 31-(b) will lighten the routine task of painting, and at the same time obtain results for economy and durability.

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THE PENNSYLVANIA RAILROAD

INSTRUCTIONS FOR PAINTING STRUCTURAL STEEL

Scope

1. These "Instructions for Painting Structural Steel" are for the guidance of the Engineering and Maintenance of Way forces in the work of preservation of steel and iron.

MATERIAL

Pigments

2. The following kinds of pigments shall be considered as basic for painting structural steel on The Pennsylvania Railroad.

A. Red Lead—Specifications for Red Lead, No. 154 (Issued Altoona).

B. Red Oxide of Iron—Specifications for Freight Car Color, No. 31-B (Issued Altoona).

C. Carbon—Specifications for Standard Black, No. 58-B (Issued Altoona).

Vehicle

3. The vehicle used for mixing the paint shall be Raw Linseed Oil complying with:

Specifications for Raw and Boiled Linseed Oil, No. 166-A (Issued Altoona).

MIXING

Formulae

4. The paint mixing shall be done in accordance with the following instructions:

Red Lead

A. No. 155, Instructions in Regard to Mixing Red Lead (Issued Altoona) when Formula No. 3 of the Table is being used.

Red Oxide of Iron

Carbon

B. No. 63-A, Instructions in Regard to Mixing Standard Black and Freight Car Color (Issued Altoona).

Volatile Thinners

5. A. Turpentine and Mineral Spirits are used in mixing paint for the following objects:

(a) To increase proportion of pigment by decreasing the proportion of oil in the ultimate dried film of paint.

(b) To secure good flowing quality when the paint is being applied so that it will brush easily.

(c) In priming coats on wood, turpentine is superior to the mineral spirits by reason of its solvent action which assists the paint to penetrate the pitchy surface of the wood. This does not apply to steel.

Turpentine

B. Turpentine shall be obtained in accordance with Specifications for Spirits of Turpentine, No. 38-B (Issued Altoona).

Mineral Spirits

C. Mineral Spirits shall be obtained in accordance with Specifications for Turpentine substitute, No. 169 (Issued Altoona).

Specifications' Revisions

6. In the event of revisions of specifications named, the latest issue governs.

Table of Formulae for Making Red Lead Paint

(Exclusive of Turpentine and Japan)

Number of Formula	Dry Red Lead Formulae							Paste Red Lead Formulae				
	Red Lead Lb.	Linseed Oil		Gallons of Paint	Red Lead Lb.	Linseed Oil		Gallons of Paint	Red Lead Lb.	Linseed Oil		Gals. of Paint
		Gallons	Lb.			Gallons	Lb.			Gallons	Lb.	
1	32	1	7.76	1.44	100	3.125	24.25	4.49	100	2.076	16.11	4.200
2	30	1	7.76	1.41	100	3.33	25.84	4.70	100	2.271	17.62	4.395
3	28	1	7.76	1.38	100	3.57	27.70	4.94	100	2.494	19.35	4.618
4	26	1	7.76	1.36	100	3.85	29.88	5.22	100	2.750	21.34	4.874
5	25	1	7.76	1.34	100	4.00	31.04	5.37	100	2.894	22.46	5.018
6	24	1	7.76	1.33	100	4.17	32.36	5.54	100	3.050	23.67	5.174
7	22	1	7.76	1.30	100	4.55	35.31	5.92	100	3.404	26.41	5.528
8	20	1	7.76	1.27	100	5.00	38.80	6.37	100	3.829	29.71	5.953

CLEANING THE METAL

Grease and Dirt

7. If the surface of the metal is not in good condition for the maximum adherence of the paint coating for the maximum length of time, a great deal of money is wasted because the cost of labor for application is much the greater part of the total cost. The following preparation of the metal surface should, therefore, be faithfully attended to:

(a) All grease, oil, dirt, scale and rust must be removed thoroughly.

(b) The paint should only be applied to a clean and dry surface.

Sand Blast

8. (a) The most effective and practicable means of cleaning old metal is by the use of the sand blast, but great care is necessary, because if kept going too long, good metal will be cut away, and the strength of the piece impaired.

(b) It should not be used to clean new metal, because it will remove the sub-oxide, or black oxide, or mill-scale, which in itself is a protection against rust formation so long as it adheres firmly.

Scrapers

9. (a) In many cases, fairly good results, depending upon the care exercised, can be obtained by the use of chisels and scrapers made from old files, hammers and wire brushes.

(b) Rotary steel brushes operated by compressed air are now being introduced, and should be given thorough trial.

Pickling

10. (a) Pickling in acid is effective for cleaning metal, but is not generally practiced in the case of structural steel, on account of the difficulty and expense of dealing with large pieces.

(b) When used in any special case, care must be taken to neutralize the acid by subsequent dipping in milk of lime or a solution of soda ash.

APPLICATION OF PAINT

Season

11. (a) The painting should be done, if possible, only in the warm summer months, but good results can be obtained, with care, from the middle of April to the middle of October.

(b) Where practicable, it is a good plan to warm the paint by placing the bucket of paint in a vessel of hot water when the atmospheric temperature is below 55 degrees.

Brushes

12. (a) The paint brush should be made with bristles that are stiff, strong and elastic, according to Specifications for Brushes No. 55-B (Issued Altoona). A round brush is generally regarded as the most satisfactory, but a flat brush about four inches wide, may also be used.

(b) Brushes should never be allowed to dry with the paint on them. They may be kept fresh and clean over night, or while carrying them from place to place, by wrapping them closely in several thicknesses of paper, the inner layer of which is wet with water.

(c) After finishing the work, the brushes should be well washed out with kerosene, then well rinsed with gasoline, and subsequently hung up to dry where they will be free from dust.

Drying

13. No succeeding coat of paint should be applied until the underlying coat has become thoroughly dry.

Coat Hardness

14. (a) Except when the paint will be continuously exposed to water, successive coats should be, progressively, more elastic, in order that the sun and air which harden the oil may not cause a hard coat overlying a softer one to crack.

(b) Inasmuch as the more red lead there is in a gallon of oil the harder will be the paint, varied degrees of elasticity in the paint film may be effected by using different amounts of pigment for the different coats.

NUMBER OF COATS OF PAINT

Similar Structures

15. Structures similar in character to those named shall be painted in like manner.

Shop Coat

16. After inspection by the Purchaser, and before shipment, new structural steel shall be painted at the shops with one coat of paint or linseed oil, as follows:

Track Bridges

Highway Bridges

(a) Track and Highway Bridges with boiled linseed oil.

Signal Bridges

Electric Power Line Bridges

(b) Signal and Electric Power Line Bridges with red lead paint according to Formula No. 5.

Signal Masts

Electric Power Line Towers and Masts

(c) Framed structural-steel Towers and Masts with red lead paint according to Formula No. 5, and tube Masts with red oxide or iron Specifications for Freight Car Color No. 31-B.

Buildings

(d) Buildings with red lead paint according to Formula No. 5.

Steel Water Tanks

(e) Steel Water Tanks and Trestles with red lead paint according to Formula No. 5.

17. The abutting surfaces of parts which will be riveted together in the shop shall be painted with one coat of red lead paint according to Formula No. 5, 25 pounds of pigment to the gallon of oil.

Field Painting

18. After erecting and before painting, and in the case of repainting work the following parts shall be spot and stripe-painted with the same kind of paint which will be used for the first coat:

(a) All rivet and bolt heads.

(b) Edges of angles and plates for a distance of an inch from the edge.

(c) Top surfaces of floor-beam and stringer-flanges and top surfaces of sub-floor bracing of track bridges.

(d) Scratches and bruises in the paint coating due to handling the material.

(e) The abutting surfaces of parts which will be riveted together in the field shall be painted with one coat of the paint which will be used for the first coat.

19. After spot-painting, the structure shall be painted as follows:

Track Bridges

Highway Bridges

(a) 1. New bridges shall be painted with one coat of red lead paint according to Formula No. 5 (Section No. 4), 25 pounds of pigment to the gallon of oil, followed by a second coat of a mixture of one-half red lead No. 5 and one-half carbon paint, Specifications for Standard Black No. 58-B, and a third coat of carbon paint Standard Black No. 58-B.

2. In repainting work, the bridges shall be painted with one coat of Standard Black No. 58-B.

3. Where a paint of light tint is required, as in the case of some bridges in certain cities, the standard light building color, Specifications for Standard Building Paints, No. 120 (Issued Altoona), and Instructions in Regard to Mixing P. R. R. Light and Dark Building Paint, No. 2 (Issued Altoona), shall be used in place of the carbon coat. Sometimes two coats of the building color will be required to cover the surface properly and make it the desired shade.

Signal Bridges

Electric Power Line Bridges

(b) 1. New bridges shall be painted with one coat of a mixture of one-half red lead No. 5 and one-half carbon paint, Specifications for Standard Black No. 58-B, and a second coat of carbon paint, Standard Black No. 58-B.

2. In repainting work, the bridges shall be painted with one coat of Standard Black, No. 58-B.

Signal Masts

Electric Power Line Towers and Masts

(c) In new and repainting work, Towers and Masts shall be painted with one coat of Standard Black, No. 58-B.

Signal Pipe Lines and Appurtenances

(d) 1. Signal pipe lines and their appurtenances shall be painted when new with one coat of red oxide of iron, Specifications for Freight Car Color No. 31-B, and one coat of carbon paint, Specifications for Standard Black, No. 58-B.

2. In repainting pipe lines and their appurtenances, they shall be painted with one coat of the carbon black, if they be not considerably rusted. If they are considerably rusted, the repainting shall be the same as for new material.

Buildings

(e) 1. Train Sheds shall be painted with two coats of red lead paint according to Formula No. 5 (Section No. 4), 25 pounds of pigment to the gallon of oil, followed by two coats of carbon paint, Specifications for Standard Black, No. 58-B.

2. Other buildings requiring color finishing shall be painted according to the tint required.

Steel Water Tanks

(f) 1. The Trestle and outside of the Tank shall be painted with one coat of red lead paint according to Formula No. 5 (Section No. 4), 25 pounds of pigment to the gallon of oil, followed by another coat of carbon paint, Specifications for Standard Black, No. 58-B.

2. The inside of the Tank shall be painted with a first field coat of red lead paint according to the quantities in Formula No. 5, but the oil used shall be pure boiled linseed oil, and to the mixture of red lead and oil 8 pounds of fine litharge mixed in 1 pint of pure raw linseed oil and 1 quart

of pure spirits of turpentine shall be added. A second coat of paint shall then be added consisting of carbon black, Specifications for Standard Black, No. 58-B.

3. All the surfaces of Track-Pans shall be painted with a first coat of red lead paint according to Formula No. 5, but the oil used shall be pure boiled linseed oil, and to the mixture of red lead and oil 8 pounds of fine litharge mixed in 1 pint of pure raw linseed oil and 1 quart of pure spirits of turpentine shall be added. The second coat shall consist of red oxide of iron, Specifications for Freight Car Color, No. 31-B, and the third coat of carbon black, Specifications for Standard Black, No. 58-B.

20. Consecutive coats of red lead or red oxide of iron paint may be darkened to different shades with suitable quantities of carbon black, as an aid in distinguishing the different coats.

21. In general in repainting work, the metal shall be painted with one coat of the paint used for the final coat, but if the metal be badly rusted, a first coat of red lead or red oxide of iron may be required, followed by the exterior coat.

Metal Encased in Concrete

22. In the case of metal which will be encased in concrete, the following conditions will be recognized:

(a) If the concrete is being added to the metal to form a composite mechanical structure in which the two materials act together to receive stress and resist strain, the metal shall not be covered with paint or coated with oil.

(b) If the concrete is being used for filling material as in the case of trough floors, or for protecting the steel, or for architectural decoration of metal beams, girders and columns, the metal work should not be painted when the concrete casing or filling will be placed within one year after delivery. If it is probable that the metal may be subjected to corrosion for a considerable period prior to use, it may be justifiable to paint the metal rather than to undergo the expense of frequent cleaning to prevent serious damage from corrosion.

STOREHOUSES OF SUPPLY

23. Supplies of The Pennsylvania Railroad specification paints are kept at the following storehouses for use by both the Maintenance of Equipment and Engineering Departments:

West Philadelphia	Wellsville	Chicago
Trenton	Cleveland	Fort Wayne
Pavonia	Olean	Logansport
Wilmington	Canton	Columbus
Harrisburg	Dennison	Altoona
Renovo	Pitcairn	Alliance

PROPRIETARY PAINTS

Service Trial

24. There are good paints of red oxide of iron, carbon and graphite made by well-established manufacturers according to proprietary formulae which may be considered available for use after the quality has been investigated and proved by the following instructions outlined below.

(a) There are certain paints which have been proved by trial to be of suitable quality for exterior coats, and others which have given unsatisfactory service. Discriminatory judgment should be exercised, therefore, so that unnecessary expense will not be incurred in having examinations of doubtful products made.

(b) When it is desirable to consider a certain paint for trial a one gallon sample should be sent to Dr. M. E. McDonnell, Chief Chemist, Altoona, Pa., and a letter of request for examination to the Chief of Motive Power, together with as much information on the details of composition and mixing as can be obtained from the manufacture, in order to ascertain if a field service trial is recommended.

(c) If the laboratory report be favorable for experimental service trial, the Chief Chemist will inform the officer of original request, the Chief Engineer and Stores Manager.

(d) A sample of the paint for proof-testing by exposure, chemical analysis or other methods desired shall be retained at the Laboratory for record, and purchases of that product may be made for 1 year. From each lot purchased a pint sample for checking must be sent to the Laboratory, and, if it does not correspond with the original sample of record, purchases will be ordered suspended.

(e) The results of service trials must be reported to the Chief Engineer, so that record may be kept of the relative value of the products.

(f) From time to time the Chief Engineer will inform the Stores Manager, and General Purchasing Agent of Products, which are considered sufficiently satisfactory for general use, after which, when deemed desirable, a stock supply may be kept at the following bases: Trenton, Wilmington, Harrisburg, Verona, Logansport.

NOTES FOR REMEMBRANCE

Corrosion

25. Corrosion of steel and iron is due to the simultaneous action of oxygen and water. When either is absent, disintegration by rust cannot occur.

Linseed Oil

26. (a) No better available vehicle than linseed oil for the pigment is known at the present time.

(b) Raw oil is more durable than boiled oil, but boiled oil makes a more varnish-like film, and does not hydrolize (soften by the chemical influence of water) as much as raw oil does, thus making it suitable for paint in contact with water.

(c) The use of driers is not objectionable if a first-class one is employed in limited quantity. Both raw and boiled oil requires a drier to hasten drying.

(d) The life of the linseed oil is a large part of the life of the paint, and it must be pure and well seasoned. Newly pressed oil is unfit for use.

(e) Linseed oil is not a lasting protection in itself to steel, as it dries with a porous film, which absorbs water, and conducts it to the metallic surface.

(f) There is no adequate substitute for linseed oil, and certain thinning mixtures for paint should only be used in times of necessity and when specially authorized.

Pigment

27. The pigment is added to the oil to fill up the pores and make it more resisting to the entrance of moisture. Therefore, a finely divided pigment is much superior to the coarse one. Some graphites are poorer than others on that account.

Red Lead

28. (a) Red lead should not be bought in paste form unless it will be used within three months after shipment by the contractor, because if allowed to stand in oil long it thickens, becomes viscous and finally hard.

Heat also accelerates the tendency of this material to cake or harden, and so it should not be stored in places of high temperature.

(b) The finely-ground red lead, Pb304, is very desirable, as nearly all the litharge, Pb0, is eliminated. This latter is acted upon by the carbonic acid in the air, which converts it, superficially, into white lead, making the red color fade out.

Red Oxide of Iron

29. The red oxide of iron is an inert pigment, but should not be made from copperas.

Paint Destruction

30. Extensive tests have resulted in the conclusions that:

(a) Every oil coating is destroyed by diluted muriatic acid and nitric acid, by gaseous muriatic acid, nitric acid, sulphurous acid, or acetic acid, by caustic alkalis, alkaline liquids (such as from fine chimney ashes) and gases, ammonia, sulphide of ammonium or solution of soda.

(b) Hot water destroys a paint coating much more rapidly than water of an ordinary temperature

Protection by Concrete

31. (a) It is well established that concrete affords protection to steel against corrosion, and it is not necessary to use paint in addition for that purpose, which adds to the cost.

(b) Oil paint weakens the bond between concrete and steel.

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THE PENNSYLVANIA RAILROAD

SPECIFICATIONS FOR SWITCH LAMPS

APPLIANCES OR ARTICLES

Scope

1. The purchase of switch lamps for use on The Pennsylvania Railroad will be guided by a combination of specifications for uniform dimensions of various parts, a statement of examination and proof-testing of the draft arrangement, and the approval for file record of a drawing in complete detail of the lamp.

LAMP BODY

Material

2. The body of the lamp shall be made of No. 18 gauge tinned sheet steel. After all parts are completely fabricated and assembled, all surfaces must be thoroughly cleaned from grease and dirt, and be dipped into a bath of molten lead and fluxing tin about in the proportions of: Tin ⅓, Lead ⅔.

Fastening

3. In the construction of the body, rivets shall be used for fastening the parts together, except where the use of bolts is especially approved.

Lens Apertures

4. (a) Four lens openings in the body for 5-inch diameter lenses shall be provided, and the coupling rings arranged so that the lens shall be completely encircled and can be readily removed and replaced. The coupling ring shall be equipped with brass screw and nut. The position of the lens must be such that the flame of the lamp is at the focal point of the lens.

(b) The lenses shall conform with "Specifications for Signal Roundels and Lenses," Plan S-487 (Basic Number).

Enameled Discs

5. The lens apertures shall be encircled with 10-inch outside diameter vitreous enameled discs of the colors specified for indicating the position of the switch points, or a ⅞-inch hood.

Socket

6. (a) The socket shall be of the size and shape to fit snugly on a tapered support ¾ inch by 1 inch at the top, $\frac{13}{16}$ inch by $1\frac{1}{16}$ inches at the base and 2½ inches high.

(b) In order to relieve it from shock, the lamp shall be carried on a spring in the socket.

(c) The socket shall be set at an angle of 45 degrees with the axis of the lens.

Handle

7. The handle shall be of No. 4 B. W. G. steel wire and shall be secured in substantial and workmanlike manner to the lamp.

Painting

8. Lamps must be coated on all external surfaces with two coats, each thoroughly baked on, of high grade baking japan. The coating after baking must be tough, hold tenaciously to the metal, must not chip or flake off, and must dry with a hard gloss finish which is not tacky.

Oil Fount

9. The oil fount shall be made in accordance with the details of Plan S-482 (Basic Number).

Burner

10. The burner shall be of the "long-time" type with a cylindrical felt wick consuming not more than ¼ ounce of oil per hour.

(a) Clips shall be provided to hold securely the chimney required by these specifications.

(b) The wick shaft for controlling the flame shall be 1⅞ inches long from the center of the flame, and fitted with a channel nut to permit control from outside the lamp body.

CHIMNEY

Material

11. The chimney shall be made of low-expansion heat-resisting glass, cylindrical in form and in accordance with the details of Plan S-482 (Basic Number).

VENTILATION

Draft

12. The lamp shall have top-draft ventilation.

Testing

13. The ventilation of a sample lamp shall be tested at the factory, or at the Altoona Laboratory, when required, as follows:

(a) By a simulated wind velocity equivalent to 80 miles per hour for two minutes.

(b) By subjection to still air temperature at 43.3 deg. C. (110 deg. F.) for two hours.

IDENTIFICATION

Name

14. The lamp and its parts shall be clearly marked for identification as follows:

(a) The Manufacturer's name on the top of the lamp.

(b) The Manufacturer's trade mark on the chimneys.

ACCEPTANCE REQUIREMENTS

Sample Lamp

15. A sample lamp exactly of the kind and quality offered for sale shall be sent to the place named by the Engineer of Standards for examination and testing.

Plan

16. (a) If the sample lamp fulfills the requirements of the examination and specifications, the Manufacturer shall furnish a dimension plan in detail of the lamp on tracing linen of the size of 16 by 28 inches out to out, with a border line 2½ inches from the left hand edge and ½ inch from all other edges; and with a space in the lower right hand corner of 3 by 7 inches for the title and the "Correct" certification of the Engineer of Standards and the "Approved" certification of the Chief Engineer of The Pennsylvania Railroad.

(b) If the plan be approved by the Chief Engineer, it shall be placed in his file for permanent record, and all lamps subsequently furnished by the Manufacturer must conform therewith.

Defect Found After Delivery

17. Switch lamps, founts, burners and chimneys which show objectionable defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the Manufacturer, who must pay the freight charges both ways and replace the defective parts with new ones fulfilling the requirements of the specifications.

Place for Tests

18. All tests and inspection, exclusive of the tests of the "sample lamp," shall be made at the place of manufacture, prior to shipment, except that check tests may be made at any other place selected by the purchaser without holding the manufactured articles at the factory or store awaiting the results of the check tests, and shall be so conducted as not to interfere unnecessarily with the operation of the factory.

Access to Works

19. Inspectors representing the purchaser shall have free entry to the works of the Manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the Manufacturer to satisfy them that the switch lamps and their accessories have been made in accordance with the terms of the specifications.

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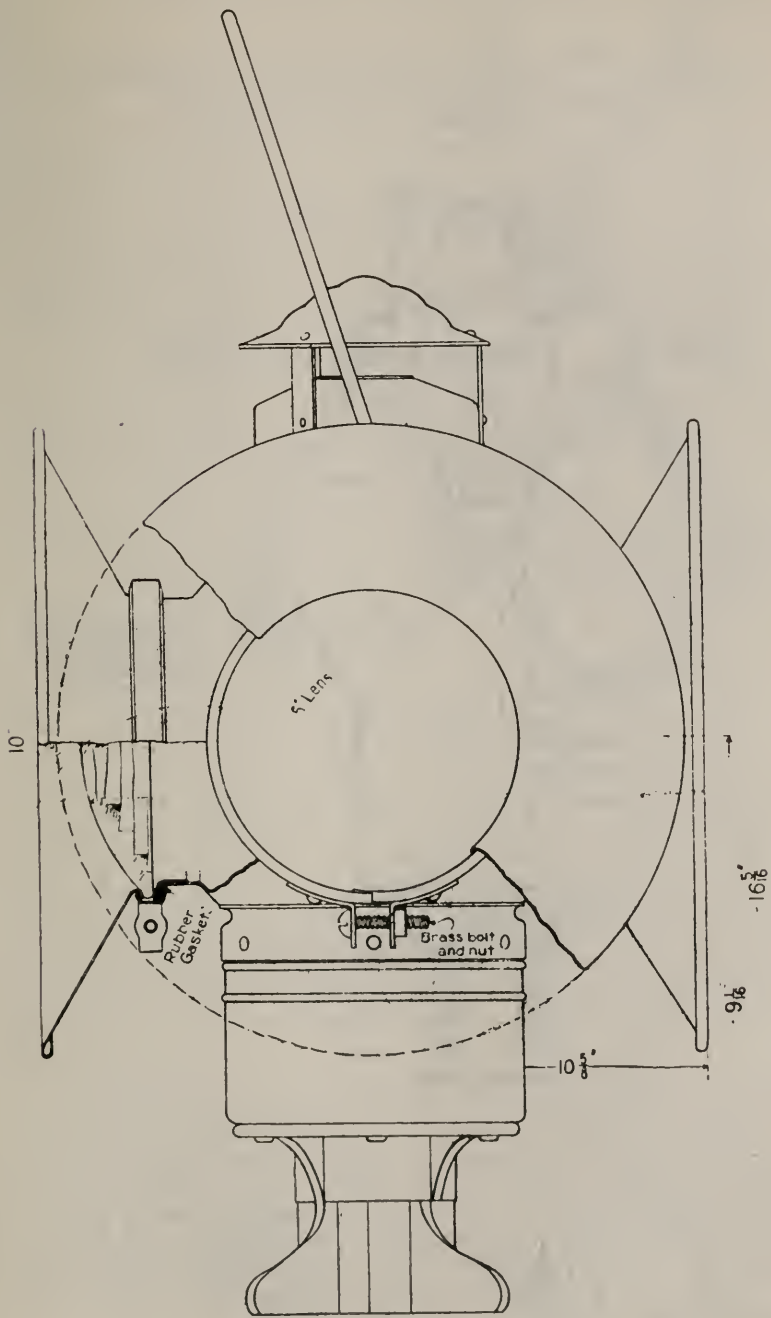
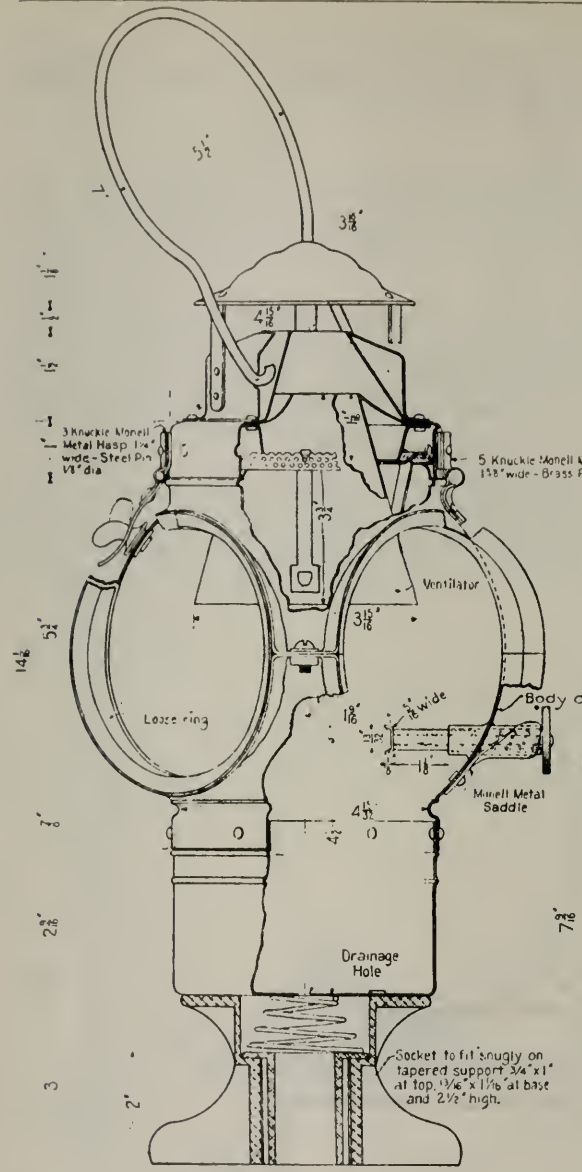
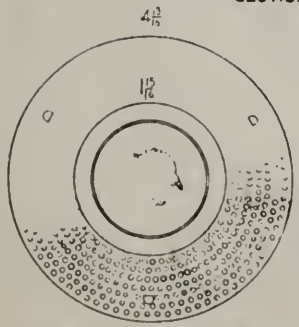


ELEVATION · SECTIONED

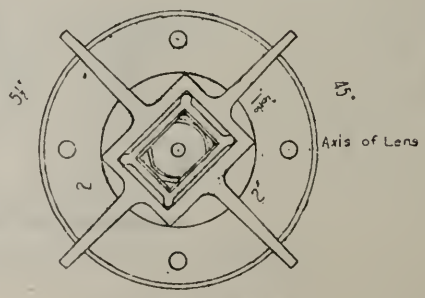
Switch Lamp—The Pennsylvania Railroad



SECTIONAL VIEW



PLAN OF VENTILATOR



BOTTOM VIEW OF BASE

REPORT OF SPECIAL COMMITTEE ON CONVENTION PROCEDURE

ACKNOWLEDGMENT

The Special Committee on Convention Procedure take this means of expressing its grateful appreciation for the helpful assistance rendered by Past Officers, Chairmen and Members of Standing and Special Committees, and the membership generally.

That railway executives of outstanding rank and reputation can join with leaders of recognized ability and international prominence, and together work with the younger members still on the lower rungs of the official ladder, for the ideals and common good of THE AMERICAN RAILWAY ENGINEERING ASSOCIATION, augers well for its future.

Our contacts, even though they have been largely by correspondence, have shown a fine healthy spirit of earnest co-operation, which has more than repaid for the time and effort expended. In preparing the report, we have drawn freely from the text of these communications and acknowledgment is made herewith.

Chicago, February 20, 1928.

To the Board of Direction, American Railway Engineering Association:

At the last annual convention, a resolution was adopted requesting the Board to consider suggestions which had been made with respect to changes in the practices and procedure of the Association. The resolution was discussed at the meeting of the Board on March 10th and it was agreed that the inquiry should be so broadened as to permit a comprehensive study of the entire subject, and a sub-committee was appointed to draft a plan in conformity therewith. Two plans were presented at the next Board meeting on May 11th and the outline designated as "Plan 2" was adopted Thereupon, a special committee from the Board was appointed by President Brumley for the purpose of undertaking the work and presenting a report thereon.

The committee at once entered actively upon its duties. Several general and numerous other meetings and conferences have been held. Questionnaires were submitted to past officers, to the chairmen and members of all standing committees, and to the entire membership of the Association. Suggestions were solicited from interested persons and studies made of the practices of other organizations with more or less similar objectives. Editorial criticisms and suggestions heretofore made by the technical press were carefully studied and discussed. Meanwhile an extensive correspond-

ence was conducted with persons who in the opinion of the committee might have information to offer that would aid in its consideration of the subject.

Before undertaking a presentation of the subject matter particularly assigned to the Committee, it is believed that a brief review of the formation, objects and subsequent development of the AMERICAN RAILWAY ENGINEERING ASSOCIATION will be helpful in its consideration.

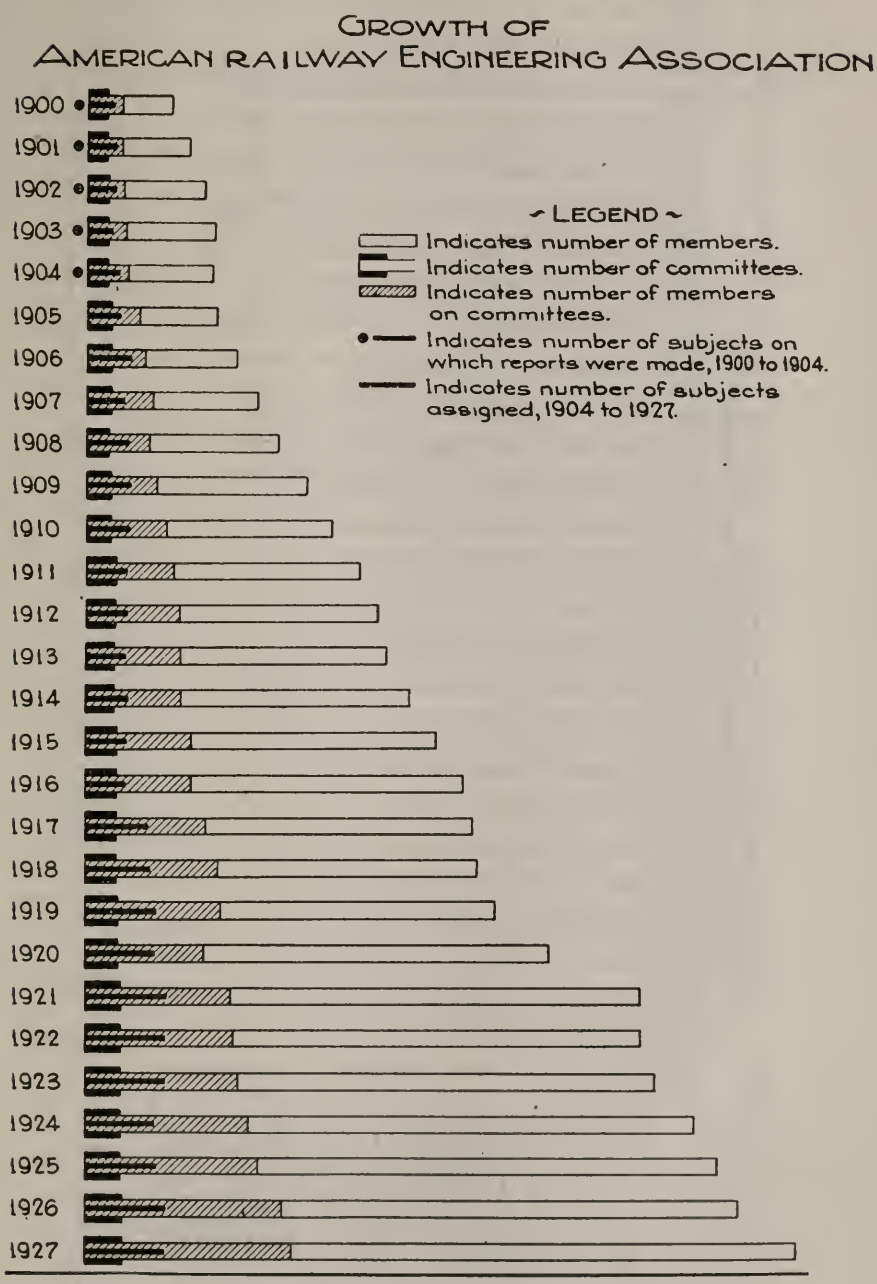
In March, 1899, a number of officers connected with engineering and maintenance departments of several of the railways of the United States and Canada undertook the organization of the American Railway Engineering and Maintenance of Way Association (to be later known as the AMERICAN RAILWAY ENGINEERING ASSOCIATION). Their efforts met with marked success and the Association started with 279 charter members at the time of the first annual convention in March of the following year. Since then its membership has increased to over 2600. Practically every railroad in North America is represented in its membership, as well as railroads in nearly every country in the world.

While formed primarily for the consideration of problems peculiar to the engineering and maintenance departments of railways, the Association has gradually broadened in scope and character until it is now easily one of the most powerful factors in the world for the development of the science of railway transportation. Every department of railway science is represented in its members, who are available for service in studying the manifold problems which are considered in its deliberations.

The object of the Association is set forth in its original constitution as the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

Its membership is composed of private individuals and not of appointed representatives from the various railways. Membership is entirely voluntary and those who join the Association do so on account of their interest in the work it is doing. Membership on its standing committees means work; it is in no sense honorary. Appointments to the committee membership are earnestly sought and when secured, the individuals usually show a lively personal interest in and a willingness to contribute time and effort to the committee work to which they are assigned. Through the extensive membership which it has among the railroads in the United States and Canada, there has been developed a remarkable co-operative spirit of generous aid and constructive assistance towards the work done and the objectives sought by the Association. It is definitely recognized as forming one of the principal educational agencies in the science of modern railroading.

The work of the Association is conducted through a Board of Direction and carefully selected standing and special committees composed of specialists in their particular field, who cover the entire field of railway engineering and allied subjects.


GROWTH OF
AMERICAN RAILWAY ENGINEERING ASSOCIATION
1900
1901
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LEGEND
Indicates number of members.
Indicates number of committees.
Indicates number of members on committees.
Indicates number of subjects on which reports were made, 1900 to 1904.
Indicates number of subjects assigned, 1904 to 1927.

AMERICAN RAILWAY ENGINEERING ASSOCIATION
ORGANIZATION OF COMMITTEES BY YEARS

Committees	1900 (1)	1901 (2)	1902 (3)	1903 (4)	1904 (5)	1905 (6)	1906 (7)	1907 (8)	1908 (9)	1909 (10)	1910 (11)	1911 (12)	1912 (13)	1913 (14)	1914 (15)	1915 (16)	1916 (17)	1917 (18)	1918 (19)	1919 (20)	1920 (21)	1921 (22)	1922 (23)	1923 (24)	1924 (25)	1925 (26)	1926 (27)	1927 (28)
I - Roadway	7	7	9	9	11	12	14	14	14	17	19	20	19	18	19	19	17	23	24	22	21	24	31	26	26	26	26	26
II - Ballast	7	7	5	9	8	11	13	13	12	14	19	15	18	21	22	20	21	21	24	23	22	21	21	22	22	25	28	25
III - Ties	9	9	9	12	11	12	11	11	13	10	13	13	17	17	18	16	18	16	20	16	16	21	23	28	28	28	28	29
IV - Rail	9	9	11	11	9	9	21	23	22	21	21	22	22	23	28	26	25	29	27	25	22	21	22	23	23	24	24	31
V - Track	10	10	12	11	8	11	13	14	15	17	21	21	25	25	22	24	28	26	20	18	21	24	21	27	27	33	34	38
VI - Buildings	14	14	7	8	8	7	8	13	13	16	12	14	18	17	14	14	13	21	20	20	17	18	17	23	23	23	23	23
VII - Wooden Bridges, Trestles	10	10	8	8	15	13	9	12	13	13	14	13	12	13	15	12	12	19	19	19	15	17	16	16	20	23	26	38
VIII - Masonry	9	9	10	9	9	12	14	11	15	17	20	19	18	21	18	15	16	20	26	24	19	24	21	24	24	21	23	26
IX - Signs, Fences & Xings	7	7	6	7	8	12	9	12	12	13	13	9	10	14	20	15	15	14	22	20	19	16	20	20	20	25	27	37
X - Signals & Interlocking	5	5	4	8	9	10	10	15	18	19	23	24	25	23	17	22	23	23	23	28	21	19	18	17	17	19	19	28
XI - Records & Accounts	7	7	10	7	10	12	12	13	11	14	23	15	14	15	10	19	20	18	18	16	12	17	19	23	23	27	28	22
XII - Rules & Organization	9	9	8	10	10	11	10	14	11	10	10	11	13	14	10	12	12	15	21	19	17	19	18	22	22	24	27	28
XIII - Water Service	7	7	6	7	9	8	10	11	12	10	11	12	14	11	10	12	12	17	19	14	16	21	21	27	27	32	32	36
XIV - Yards & Terminals	11	11	15	11	10	10	11	14	13	18	20	18	21	19	24	24	22	25	24	23	22	26	27	32	32	32	37	39
XV - Iron & Steel Structures	-	-	9	10	10	11	14	17	11	16	12	15	17	17	18	21	22	25	28	27	24	29	31	32	32	34	37	35
XVI - Economics of Ry. Location	-	-	-	-	-	12	14	15	17	-	15	15	14	12	16	20	21	26	-	29	24	21	21	20	20	18	21	29
XVII - Wood Preservation	-	-	-	-	-	-	-	-	-	17	16	13	13	12	12	12	14	15	20	18	19	22	24	24	24	23	26	26
XVIII - Electricity	-	-	-	-	-	-	-	-	-	-	-	9	13	18	21	21	18	19	20	21	15	20	20	23	23	23	22	23
XX - Uniform Gen. Con. Forms	-	-	-	-	-	-	-	-	-	7	-	12	11	13	12	10	10	11	13	13	10	17	16	19	19	21	20	23
XXI - Econ. of Ry. Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	30	20	21	27	34	34	33	34	37
XXII - " " " Labor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	22	16	19	20	21	21	24	30	27
XXIII - Shops & Loco. Terms	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	21	25	25	27	29	31
XXIV - Co-operative Relations with Universities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	18
- Stresses in Track	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	22	22	21	21	21	21	21	26	20	20	20	19
- Standardization	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	25	26	26	26	26	26
- Clearances	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	12
- Conservation	-	-	-	-	-	-	-	-	-	-	-	12	10	11	10	12	6	12	13	13	11	17	-	-	-	-	-	-
- Grading & Insp. of Lbr.	-	-	-	-	-	-	-	-	-	-	-	6	8	-	-	7	6	10	-	-	-	-	-	-	-	-	-	-
- Brine Drippings	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Special Classification of Track	-	-	-	-	-	13	13	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	121	121	129	137	145	186	206	234	222	249	282	311	332	334	336	375	373	427	472	481	420	515	521	540	578	611	695	715
Number of Committees	14	14	15	15	15	17	17	17	16	17	17	22	21	20	20	22	22	22	22	23	23	25	24	24	24	24	26	26

At the present time, there are twenty-three standing, three special, and fifteen contact committees, having 715 members who are actively engaged in handling 140 assignments. It was a wise provision of the founders that the organization should be so arranged that definite progress should be made each year by each committee and the net results of the Association's work would at all times represent mutual consistent progress in the various fields and that the results should be promptly available for distribution to the railways and others requiring them. A critical review of the truly wonderful progress which has been made during these twenty-eight intervening years, reveals that the founders builded better than they knew, and that their belief in the need and possibilities of such an Association were truly well founded.

Committee members are selected with due regard for their special qualifications for dealing with subjects within the scope of the committee to which they are assigned and their knowledge of the diverse, physical, climatic, traffic and other conditions to be met with in different parts of the North American continent, to which are applied scientific and economical principles and practices in keeping with modern requirements for the railway transportation service.

It was not the thought of the founders of the Association that any one of these committees could cover the investigation of its entire field within any specified time. The standing committees are therefore made continuous and changes in their membership are brought about gradually so as not to interfere with the continuity of the work assigned to them.

Appropriate subjects for investigation within its own field are assigned annually to each committee. As one or more of these subjects is finally reported upon, additional subjects are assigned for research and study, selections being such as to fulfill the requirements of the trends of advancing transportation, so that each committee is gradually covering more and more of the ground allotted to it. To each committee is also assigned the duty of making a critical review from year to year of the work heretofore reported by its predecessors, in order that the results may always be in keeping with modern-day requirements of the railway industry.

The standing and special committees are charged with the investigation of current practices, the collection of all facts in regard to an assigned subject, the analysis of the data thus obtained, and the presentation of conclusions as to what constitutes the best practices under various conditions.

In their final reports, the technical terms used are defined and when pertinent, a brief historical outline is included, together with an analysis of the important elements of the matter under consideration. The disadvantages of other practices and the advantages of the practices embodied in the conclusions of the committee are stated. The final conclusions are presented in concise form for consideration or adoption, or otherwise, by the Association at its annual convention held at Chicago in March of each year.

Particular subjects assigned to a standing committee are usually allotted to sub-committees, the members of which are selected from among its own membership, with a view of having the assignment handled by specialists on that particular subject. The work of the sub-committee is later reviewed and discussed by the committee as a whole, when changes or revisions are made, as the circumstances warrant.

Thus it will be seen that before the report on any assignment is submitted to the Association, it has been prepared and discussed by a competent sub-committee of specialists and their report has been critically analyzed and approved by the standing committee composed of members drawn from various branches of railway service.

When the report has reached this stage, it is issued in bulletin form to the entire membership of the Association in order that they may have an opportunity of becoming fully conversant with it before presentation for final disposition at the next annual convention of the Association.

The work of both the sub-committees and the standing committees affords opportunity for continuous contact with the needs of the railways, the development of technical details, and for studying the mental processes and methods of approach of able men engaged in similar work. Not the least of the advantages of Committee work is the opportunity of learning something of human nature and its reactions, as it is necessary for members to act both as a unit of the sub-committee and of the standing committee, as well as individuals.

The American Railway Engineering Association functions as the Engineering Division of the American Railway Association, its President and Secretary serving as Chairman and Secretary, respectively, of that section. Allied with it is also the Electrical Section, represented by Standing Committee XVIII—Electricity, and through its Standing Committee X—Signals and Interlocking, it forms a direct contact with the Signal Section of the American Railway Association.

The American Railway Engineering Association is probably one of the most important engineering associations in the world. Its work now constitutes a recognized standard practice for railroading generally in the United States and Canada, and has a powerful influence on the work of other countries. The reports and recommended practice serve as a criterion for State and Federal bodies and Federal bureaus. Through its standing committees, contacts are being increasingly formed with various organizations and branches of industry concerned with national and international standardization, simplification and economical practice.

The great advances in development and the changes in economic life have brought demands for broader and more comprehensive application of science in railway transportation, the results of which are to require a better understanding, as well as a more scientific application of the agencies through which it can be obtained. This, in turn, finds expression in greater obligations on the standing and special committees, by which, under the plan of work of the American Railway Engineering Association, research, study and investigations of railway engineering problems are made.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

COMPARISON OF REPORTS AND DISCUSSIONS BY WORKING COMMITTEES
1900 - 1927, INCLUSIVE.

Working Committees	Annual Reports Made	Reports Submitted Printed Pages			Discussions Written & Oral, Pages			Percentages		
		Total	Maximum	Average	Total	Maximum	Average	Reports To Total	Discussions to Total	Discussions to Reports
I - Roadway	28	1,075	178	38	261	70	9	4.62	7.83	24.3
II - Ballast	27	769	206	28	183	29	7	3.32	5.42	23.8
III - Ties	27	1,121	134	43	177	26	6	5.06	5.24	15.1
IV - Rail	27	3,892	559	140	251	22	9	16.39	7.44	6.6
V - Track	27	808	56	30	300	38	11	3.49	8.84	37.1
VI - Buildings	26	822	144	32	158	28	6	3.55	4.64	19.2
VII - Wooden Bridges & Trestles	27	923	89	34	243	48	9	3.99	7.19	26.3
VIII - Masonry	28	1,004	107	36	288	58	10	4.36	8.53	28.7
IX - Grade Crossings	25	860	103	34	98	19	4	3.72	2.90	11.4
X - Signals and Interlocking	27	821	137	30	166	30	6	3.55	4.92	20.3
XI - Records and Accounts	27	948	167	35	123	23	5	4.10	3.64	13.0
XII - Rules and Organization	25	476	82	19	164	23	7	2.06	4.83	34.5
XIII - Water Service	26	896	79	35	107	23	4	3.87	3.17	12.0
XIV - Yards and Terminals	27	1,399	134	52	125	15	5	6.05	3.70	8.9
XV - Iron and Steel Structures	26	1,814	309	70	269	36	10	7.84	7.97	14.8
XVI - Economics of Railway Location	19	489	101	26	107	24	6	2.20	3.15	21.9
XVII - Wood Preservation	19	1,364	222	72	49	10	3	5.95	1.45	3.6
XVIII - Electricity	18	994	181	55	41	13	2	4.30	1.21	4.1
XIX - Conservation of Natural Res.	12	189	30	16	13	6	1	0.82	0.38	6.9
XX - Uniformity Gen.Cont.Forms	18	404	137	22	56	16	3	1.74	1.66	13.9
XXI - Economics of Ry.Operation	10	488	70	48	15	4	1	2.08	0.40	3.1
XXII - Economics of Railway Labor	10	459	100	46	82	29	8	1.98	2.43	17.8
XXIII - Shops & Locomotive Terminals	7	296	129	42	8	4	1	1.27	0.24	2.8
XXIV - Co-Operative Relations Univ	4	9	4	2	7	6	2	0.01	0.21	78.0
- Stresses in Track	13	693	186	53	18	8	1	3.00	0.53	2.6
- Standardization	6	50	31	8	30	6	5	0.22	0.89	60.0
- Grading of Lumber	7	104	62	15	27	19	4	0.45	0.80	26.0
- Miscellaneous	-	17	-	-	13	6	-	0.01	0.39	-
Total		23,185			3,379			100.00	100.00	

Sectional Meetings

It has been necessary to add other standing and special committees from time to time until there are now nearly double the original number. This has led to a belief among some of the members that better results would be accomplished if sectional meetings were held, thereby permitting members to attend meetings at which reports are being made upon the subjects in which they are more directly interested, and in this manner, the entire problem be correspondingly advanced as several sectional meetings could be in progress at the same time during the Convention.

GROWTH OF A. R. E. A.

Year	No. of Committee	Total Number of Members on Committee	Subjects Assigned	Total Number of Members
1900	14	121	46*	297
1901	14	121	49*	359
1902	15	129	41*	406
1903	15	137	20*	454
1904	15	145	62*	437
1905	17	186	57	463
1906	17	206	71	528
1907	17	234	65	602
1908	16	222	74	680
1909	17	249	77	784
1910	17	282	77	869
1911	22	311	67	967
1912	21	332	69	1,030
1913	20	334	68	1,066
1914	20	336	76	1,147
1915	m22	375	73	1,236
1916	22	373	69	1,336
1917	22	427	112	1,370
1918	23	472	113	1,387
1919	23	481	124	1,449
1920	25	420	124	1,638
1921	24	515	141	1,951
1922	24	521	138	1,960
1923	24	540	140	2,010
1924	24	578	122	2,148
1925	24	635	125	2,227
1926	26	661	136	2,304
1927	26	695	136	2,511
1928 †	26	715	140	2,607

* - Number of subjects discussed.

† - 1928 does not appear on chart.

Data shown for first of each year.

Suggestions have been made to group related subjects which would be reported and discussed at these sectional meetings. It has been held that by this means, more discussion of the subjects by those especially qualified or interested therein would be afforded, thereby securing better and more complete results than is possible under existing practice. In support of this, comparisons are made with the procedure of the American Society of

American Railway Engineering Association

NUMBER OF PAGES REPORTED IN PUBLISHED PROCEEDINGS OF FORMAL REPORTS AND DISCUSSIONS FOR YEARS 1900 - 1927, INCLUSIVE.

A. R. E. A. COMMITTEES	1900 Rep	1900 Dis	1901 Rep	1901 Dis	1902 Rep	1902 Dis	1903 Rep	1903 Dis	1904 Rep	1904 Dis	1905 Rep	1905 Dis	1906 Rep	1906 Dis	1907 Rep	1907 Dis	1908 Rep	1908 Dis	1909 Rep	1909 Dis
I - Roadway (Graduation)	4	7	10	11	19	21	28	70	52	8	26	28	102	5	46	4	42	16	178	8
II - Ballast	5	20	5	3	5	16	-	-	17	19	10	1	7	29	19	8	4	1	44	8
III - Ties	3	13	12	17	14	12	-	-	32	26	12	4	36	16	49	13	73	0	32	12
IV - Rail	8	14	12	16	7	13	1	1	8	8	-	12	8	17	-	-	50	22	59	2
V - Track	5	8	44	12	13	23	-	-	24	38	12	2	16	7	49	16	22	24	54	32
VI - Buildings	2	7	-	-	30	21	-	-	12	20	12	9	8	3	24	17	20	28	22	10
VII - Wooden Bridges & Trestles	2	4	32	22	3	5	-	-	8	7	31	48	33	8	49	15	48	21	64	14
VIII - Masonry	2	4	10	27	34	26	15	58	35	30	28	4	26	15	9	0	9	1	104	11
IX - Grade Crossings, etc.	-	-	103	4	-	-	-	-	62	19	1	0	22	6	7	1	2	0	35	1
X - Signaling & Interlocking	3	3	4	5	2	3	32	30	-	-	62	7	52	11	21	15	47	20	137	25
XI - Records & Accounts	2	5	9	2	46	14	-	-	121	23	32	10	53	10	21	11	15	17	45	4
XII - Rules & Organization	5	8	5	10	-	-	-	-	-	-	3	-	4	4	5	10	2	6	5	12
XIII - Water Service	4	5	12	4	-	-	-	-	11	3	23	8	10	3	17	6	45	4	79	11
XIV - Yards and Terminals	2	7	10	12	23	7	25	8	79	1	35	3	39	14	-	-	58	15	83	2
XV - Iron & Steel Structures	•	•	•	•	17	16	125	30	6	4	250	31	35	36	36	4	71	16	20	2
XVI - Economics of Railway Location	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	9	28	0	-	-
XVIII - Wood Preservation	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	54	7
XVIII - Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XIX - Conservation of Natural Resources	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XX - Uniform General Contract Forms	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	137	4
XXI - Economics of Railway Operation	-														-	-	-	-	-	-
XXII - Economics of Railway Labor	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XXIII - Shops & Locomotive Terminal	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XXIV - Co-Operative Rel. with Universities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Stresses in Railroad Track	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Standardization	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Clearances	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Grading of Lumber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Brine Drippings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	3
Special - Specifications for Cement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Classification of Track	-	-	-	-	-	-	-	-	-	-	-	-	2	6	-	-	-	-	-	-
Total	47	105	268	145	213	177	226	197	467	206	537	167	453	190	453	129	536	191	1161	168

A. R. E. A. COMMITTEES	1910 Rep	1910 Dis	1911 Rep	1911 Dis	1912 Rep	1912 Dis	1913 Rep	1913 Dis	1914 Rep	1914 Dis	1915 Rep	1915 Dis	1916 Rep	1916 Dis	1917 Rep	1917 Dis	1918 Rep	1918 Dis	1919 Rep	1919 Dis
I - Roadway (Graduation)	26	9	62	1	14	0	30	0	18	14	36	13	12	0	47	0	5	2	34	7
II - Ballast	24	3	8	8	206	2	25	4	40	3	16	12	46	8	36	8	44	3	34	2
III - Ties	40	5	41	1	70	11	64	1	134	13	44	4	38	5	67	3	35	-	13	5
IV - Rail	325	17	559	6	304	16	410	3	231	13	282	11	296	1	313	0	136	6	202	7
V - Track	10	12	46	16	16	14	35	11	38	3	24	10	24	6	37	16	20	2	20	7
VI - Buildings	27	10	36	0	5	0	42	1	19	4	46	1	6	1	5	2	28	1	8	4
VII - Wooden Bridges & Trestles	55	6	32	18	[illegible]	0	46	6	6	8	14	2	28	0	19	13	27	10	37	1
VIII - Masonry	60	1	102	8	46	4	8	0	56	3	32	1	20	14	78	12	44	5	54	5
IX - Grade Crossings, etc.	17	3	3	0	5	0	40	5	46	12	87	6	12	5	75	5	64	6	15	-
X - Signaling & Interlocking	34	7	34	2	8	0	10	0	30	3	13	10	11	1	78	1	27	8	46	7
XI - Records & Accounts	40	3	11	2	3	0	6	-	38	3	6	2	8	0	63	0	5	2	3	3
XII - Rules & Organization	9	5	33	3	4	11	6	23	6	4	10	0	23	28	6	4	14	0	3	0
XIII - Water Service	76	7	54	23	28	3	32	1	20	0	37	0	9	3	31	5	30	1	50	0
XIV - Yards and Terminals	60	1	28	9	6	1	42	10	48	6	31	1	20	2	50	1	34	2	25	7
XV - Iron & Steel Structures	45	7	309	11	8	8	16	8	104	11	76	20	86	6	34	1	96	9	46	13
XVI - Economics of Railway Location	78	24	9	1	2	0	73	24	6	0	48	22	2	0	20	7	-	-	4	5
XVIII - Wood Preservation	122	0	52	2	10	110	16	0	58	7	66	1	36	0	180	2	16	-	40	3
XVIII - Electricity	3	0	86	8	50	13	26	0	16	1	40	0	7	0	161	2	38	9	13	1
XIX - Conservation of Natural Resources	9	0	6	-	30	0	11	6	8	0	15	0	8	0	27	3	20	1	17	1
XX - Uniform General Contract Forms	-	-	11	-	10	16	11	14	3	1	13	1	9	6	7	0	17	1	9	1
XXI - Economics of Railway Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44	4	13	0
XXII - Economics of Railway Labor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72	29	47	5
XXIII - Shops & Locomotive Terminal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XXIV - Co-Operative Rel. with Universities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Stresses in Railroad Track	-	-	-	-	-	-	-	-	-	-	2	1	2	0	2	0	186	0	2	1
Special - Standardization	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Clearances	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Grading of Lumber	-	-	62	6	12	2	0	0	1	0	12	0	8	0	7	19	-	-	-	-
Special - Brine Drippings	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Specifications for Cement	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Special - Classification of Track	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1062	121	1586	126	841	111	951	117	926	109	950	118	711	82	1363	104	1002	101	735	85

A. R. E. A. COMMITTEES	1920 Rep	1920 Dis	1921 Rep	1921 Dis	1922 Rep	1922 Dis	1923 Rep	1923 Dis	1924 Rep	1924 Dis	1925 Rep	1925 Dis	1926 Rep	1926 Dis	1927 Rep	1927 Dis	Total Pages Report	Total Pages Discuss
I - Roadway (Graduation)	22	6	28	6	33	7	13	1	24	5	16	5	70	3	76	4	1,075	261
II - Ballast	46	2	32	5	29	1	19	3	15	0	21	2	8	3	4	9	769	183
III - Ties	40	7	60	3	30	6	23	0	23	4	72	1	46	0	18	0	1,121	177
IV - Rail	179	8	78	4	47	13	27	6	53	15	43	6	157	12	138	2	3,692	251
V - Track	26	7	46	3	46	7	52	3	39	8	22	6	56	7	12	0	808	300
VI - Buildings	16	1	46	1	123	1	62	0	14	4	10	4	144	2	55	6	822	158
VII - Wooden Bridges & Trestles	60	0	62	11	21	6	25	1	6	2	38	11	64	3	89	1	923	243
VIII - Masonry	64	8	22	2	34	5	10	1	18	12	11	14	14	0	59	16	1,004	288
IX - Grade Crossings, etc.	14	0	48	6	36	1	11	4	37	5	37	5	46	1	35	3	660	98
X - Signaling & Interlocking	14	0	10	0	3	1	1	0	2	5	81	2	37	0	22	0	821	166
XI - Records & Accounts	56	0	24	1	15	0	31	6	167	0	86	2	40	0	8	3	948	123
XII - Rules & Organization	18	4	49	4	43	1	31	2	70	10	82	6	15	8	25	5	476	164
XIII - Water Service	34	2	37	0	45	2	31	0	29	3	46	8	67	3	39	2	698	107
XIV - Yards and Terminals	214	0	12	0	20	2	134	4	69	0	115	1	36	7	101	2	1,399	125
XV - Iron & Steel Structures	92	16	30	12	65	3	60	0	79	0	13	0	25	2	69	3	1,814	269
XVI - Economics of Railway Location	20	1	20	2	2	1	4	0	5	0	8	2	6	2	53	8	489	107
XVIII - Wood Preservation	44	1	36	0	83	4	99	3	222	5	65	4	89	0	74	0	1,364	49
XVIII - Electricity	54	3	88	1	45	1	109	0	63	0	36	1	58	1	51	0	994	41
XIX - Conservation of Natural Resources	22	1	16	1	-	-	-	-	-	-	-	-	-	-	-	-	189	13
XX - Uniform General Contract Forms	8	0	20	0	11	0	30	2	28	0	26	2	21	8	33	0	404	56
XXI - Economics of Railway Operation	34	1	70	0	48	4	52	3	41	0	69	0	25	2	86	1	482	15
XXII - Economics of Railway Labor	10	2	8	14	37	12	31	8	100	5	81	4	57	1	16	2	459	62
XXIII - Shops & Locomotive Terminal	-	-	63	0	129	1	3	0	31	4	26	1	29	0	15	2	296	8
XXIV - Co-Operative Rel. with Universities	-	-	-	-	-	-	-	-	‡	0	2	0	4	6	3	1	9	7
Special - Stresses in Railroad Track	170	1	1	0	1	1	156	4	3	0	165	8	2	1	1	1	693	18
Special - Standardization	4	6	4	2	4	11	4	7	3	4	-	-	-	-	31	0	50	30
Special - Clearances	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-
Special - Grading of Lumber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	104	27
Special - Brine Drippings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	4
Special - Specifications for Cement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Special - Classification of Track	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	8
Total	1291	77	872	78	950	91	1018	58	1141	91	1173	95	1132	72	1113	72	23,165	3,379

NOTE:
‡ - Report not printed.
• - Included in Committee VII
Reports include illustrations and exhibits.
Discussions includes letters read on floor of convention.

Civil Engineers, the American Society of Mechanical Engineers, the American Society for Testing Materials, and other national organizations.

The American Railway Engineering Association differs fundamentally from these and similar organizations in that all the members are interested in the broad subject of railroads and very few have their interest limited to one phase of the subject.

The present-day practice of railway engineering consists of the selection and application of the best methods in both the general and specialized subjects; therefore, Chief Engineers, Engineers of Maintenance, Division Engineers and other railway officers, and those who have the ambition to become such, should be and are interested in both the general and specialized subjects, and no procedure may be considered good that will prevent the hearing of all subjects, whether general or special, by all those members who desire to hear them. Few, if any, subjects are reported by the standing or special committees that are not of specific interest or value to the majority of members of the Association, including the younger as well as the older, because they all have to do to a more or less extent with the work of every member, whereas in other associations made up of men in private practice and those who specialize in some particular line or branch of engineering, the interest of individuals in other branches is more or less academic. Any plan which would confine the members' attendance to a portion only of the reports, must inevitably reduce both the interest and the value of the work in the Association.

That some do not take advantage of the opportunities for broader contacts with various phases of railway service, is the misfortune of those members rather than of the Association.

It is our belief that Sectional meetings tend to narrow down interest by dealing with specialized subjects, whereas one of the main advantages of the present practice is the broadening influence of hearing all of the committee reports and avoiding the limitations which would inevitably result from sectional meetings.

Replies to the questionnaires from past officers, chairmen of standing committees and the membership generally are overwhelmingly against the proposal, substantially for the reasons stated.

Three-day vs. Four-day Convention Period

With the increase in membership and importance of the Association, has come a corresponding increase in its activities and reports. This has been met by closer scheduling of the convention hours in order that the entire program may be presented during the three-day session. It is felt by some of the members that the point of saturation has been reached and that this cannot be relieved without either curbing the reports or reducing the effective work of the convention, and that they would meet this situation by increasing the present three-day convention period to four days.

There is much to be said in favor of additional time for convention requirements. It has been given careful study in former years by the Board of Direction, with the results as aforesaid.

The work of our predecessors and of the work and results of past conventions have been reviewed in the light of present-day requirements, and systematic inquiries of the cause and effect have also been invited, from which it would appear that the three-day convention period should be adhered to as long as practicable, it being the view of the majority that many members who desire to attend all sessions of the convention will find it difficult to remain for the extra day, and from the information before us, it seems probable that it will have some effect on the annual attendance.

This question will ultimately be decided according to the needs of the Association. Meanwhile, it is believed that before the four-day session becomes necessary, consideration should be given to the possibilities of lengthening the present schedule of the convention or by other expedients, resorting if necessary to one or more night sessions as occasion demands, as was the practice in former years.

Decreasing Number of Subjects Reported Upon

Suggestions have also been made in favor of decreasing the number of subjects assigned to standing committees, on the theory that it will enable a greater amount of time to be devoted to the consideration of committee reports and other convention activities; also that it will permit a greater concentration both on the part of committees and membership, and that the variety and number of subjects under investigation is so extensive that the members do not have opportunity to properly inform themselves thereon, irrespective of the time in which reports are received.

If the objectives of the American Railway Engineering Association are to be properly attained, viz., the advancement of knowledge pertaining to the science of railroading (which in reality is the science of transportation) all matters relating thereto should at all times be kept in the foreground and constructively advanced by research, analysis and creative discussion. It is, and should be, the purpose of the Board of Direction to see that this continues so, and that subjects of such number and character are assigned as will best accomplish this result.

As the membership increases, the number of men assigned to work on committees is certain to increase similarly and if these men are to be kept busy and interested, it would seem desirable to increase, if necessary, rather than decrease, the number of subjects assigned to them, when by so doing the purpose for which the Association exists may be correspondingly advanced. As long as there are subjects of this character requiring investigation, and as long as men are ready and willing to devote their time to the research work necessary for its accomplishment, it would be unwise to alter the present practice. The replies to the questionnaire are overwhelmingly against any change, the standing committees reporting in the ratio of five to one against a reduction of subjects.

Decreasing Number of Standing Committees

Much of the great advance which has been made in the scientific and economical operation, maintenance and management of the railways, has

come through a better and more comprehensive understanding of the complex mechanisms through which the railways function. It is no longer sufficient to consider its problems through the medium of departments or sub-divisions. Rather must its further successful advances be secured through broader and more sympathetic understanding of the significance of inter-relationships in order that the railways may continue to remain in the forefront as the principal agency for producing safe, convenient and economical transportation for the general public, while assuring a fair return for its owners or investors.

Proportionately therefore, and because of its importance as one of the principal factors in this great enterprise, the American Railway Engineering Association must continue as it has in the past to broaden in scope and character and in the amount of its work and activities, and every act of its directing agencies should be with this purpose clearly in mind. It follows that its activities should be broadened, not restricted, and that its plans be so laid that its work will be increased and not diminished.

In conformity with this purpose, subjects are assigned to certain standing committees which are frequently found to be inter-related with the assignments of other standing committees, and conditions often must develop during the process of their investigations which are not always apparent when making original assignments. This results in the overlapping of one standing committee into the field of another.

For this and similar reasons, it is held by some that better results will be secured if several of the principal standing committees were now combined so that the inter-related or overlapping subjects may be thus handled by the combined committee. We do not share this belief. Rather, we conclude that the more recent practice of the Board of Direction of requiring collaboration between independent committees on those features which are thus related, gives assurance of better results.

For the purpose of consistently adjusting any differences should they exist, committee chairmen have been requested to advise the Board of Direction through the Secretary on such matters in order that they may be clarified, co-related or interpreted as the circumstances warrant. There appears no good reason why this plan of action should be altered at this time.

Recognizing the distinction which must always be borne in mind between committees of volunteer workers and committees composed of men representing organizations who devote all or the major part of their time to the work at hand, it is our belief that experienced independent committees so organized as to cover the well defined fields of railway operation, working on broad lines and with proper contacts on inter-related subjects, will maintain a better interest and secure more satisfactory results than through organizations rendered more or less inarticulate through mass action.

Minority Reports

Suggestions have also been made with respect to majority and minority reports; largely, however, with the view of encouraging discussion, which will be referred to later.

Some say that minority reports are desirable as affording opportunity to present important differences of view in the committee. Others, with equal force, claim that they are undesirable and confuse the membership, while leaving the status of subjects in a more unsatisfactory position than before presentation. These and other arguments of like nature are advanced and correspondingly opposed by the membership.

It is our belief that minority reports are not in general desirable and should not be presented unless all means have been taken to adjust the differences in the committee. As a general rule, final reports should not be presented until they have the unqualified endorsement of a large majority of the committee members.

Until this has been accomplished, it is believed that in keeping with the purpose for which the Association has been created, such subjects should be continued as progress reports until substantial agreement has been obtained. Brief, concise statements from a committee in the form of progress reports, which shall include a statement of the differences with the reasons therefore, will usually provoke constructive discussion, or information bearing on the subject will, as a rule, be found more readily available to assist the committee in ultimately reaching definite conclusions. Usually such cases take care of themselves through the medium of suitable advance preparation for discussion, particularly if they be in writing and not printed with the report, the differences being interpreted by the author in synopsis.

Volume of Reports

With the growth of the American Railway Engineering Association has come a corresponding increase in its publications. These consist essentially of reports from the standing and special committees and monographs containing papers of special merit from the membership on subjects relating to the objectives of the Association. These publications reach the membership in the form of Bulletins issued during the year. Later, the committee reports and the discussions which follow at the annual convention are bound up and issued in the form of Proceedings, and cover the work performed by the Association during the fiscal year.

It is believed on the part of some of the members that the reports have now become too voluminous and should be reduced, either by a careful paring down of irrelevant matter or by some other method that would insure a reduction in the amount of published material.

It is also pointed out that there is a tendency on the part of committees for duplication and to include questionnaires, answers, etc., which are unnecessary, and that either a committee of the Board or some person or

persons especially trained in such matters, should be provided to cull out unnecessary material.

A Board committee on supervision of reports is impracticable by reason of the labor required of the Board members and because it will discourage committee work and the presentation of results of research into scientific discovery, strength of materials, engineering application of mechanics, description of important construction work, especially when involving new and original ideas and methods, suggested improvements in specifications, designs and rules for awarding contracts, etc.

Each committee should be free to print as much as they consistently need to properly present their report and explain the reasons for and against any given idea. There are a number of subjects assigned to various committees which require questionnaires and in order to incorporate the opinions of the various railroads of the United States and Canada, which in many cases are rather extensive, it is believed it is very beneficial, as an expression from possibly one railroad may peculiarly fill the needs of railroads which are looking for just that information. Clarity and conciseness is important, and care and consideration should be the guide.

There can be no question but what it is possible to boil down many of the reports more than is now being done, but the fact cannot be overlooked that the chairmen of the committees and sub-committees are volunteer workers with widely different ideas regarding the extent to which brevity is desired, and that as a practical matter, it is not best to insist that they condense their reports to the minimum. As the membership increases, the number of members serving on committees will increase and the output of work will correspondingly grow. The very success of the Association in attracting more men into its membership is giving rise to the increase in the volume of reports, and while this may be considered as grounds for criticism on the part of some members, it is in reality an evidence of the virility of the Association.

The easiest way to reduce the volume of reports is to discourage work on the part of the members of a voluntary organization. There are notable cases where this has been done. In one instance which has come to our notice, this has been so admirably accomplished, that it is now an open question among the members as to whether the organization should not be abolished.

As a general rule, the standing committees do pay more attention to data supplied for ultimate printing in the Manual of Recommended Practice and while it is no doubt true that some of it can be clarified, simplified and reduced, it will usually be found that in the succeeding revisions which are constantly being made of material for the Manual, that in the end this objective is pretty generally reached.

Early Publication of Committee Reports

There appears to be a widespread belief among the members that committee reports are received too late to permit proper study before the

annual convention. The question is not new. It is a problem over which the Board of Direction and the Secretary have been deeply concerned for years. If it can be permanently corrected, many of the conditions for which remedies have been suggested would, in our opinion, satisfactorily adjust themselves.

There are also other advantages which would be secured, among them being a better opportunity for the standing committees of the Board, on OUTLINE OF WORK and on PERSONNEL, to more promptly arrange the working program for the succeeding year and thus permit standing committees to organize and get to work promptly after the close of the convention, when the interest is at its greatest and committee members are more closely in touch with the reactions of the convention.

Through the co-operation of the standing committees, the reports have been received this year at an earlier date than for many years. This in turn enabled committee assignments on subjects and personnel to be tentatively prepared in a majority of cases by December 15th. This would indicate that the plan is feasible and practicable, and in it rests the solution of many of the minor difficulties in convention procedure, while at the same time serving to increase the interest in the work of the Association.

The questionnaire shows a very large majority in favor of some action of this character.

Grouping of Reports

It has also been recommended that in the Convention Program the reports of the standing committees be grouped in such a way that related subjects shall follow in logical sequence, thereby causing the least disturbance of interest at the convention in the presentation of subjects which are closely related.

It is claimed that by this method members who cannot attend all sessions of the convention can better arrange their plans for taking part in the presentation and discussion of subjects in which they are particularly interested.

This subject has also in the past been given careful consideration by the Board of Direction and the Secretary. The difficulties attending it are due in no small degree to the lateness in which committee reports are received, and interference with this and many other matters affecting convention procedure.

If the difficulty of late reports is overcome, it should also enable the Board of Direction to make this desirable improvement, with the closing date of December 1st for committee reports to be in the hands of the Secretary. In this way, the preparation and printing of annual bulletins may be so arranged that they can be mailed by the Secretary not later than January 15th and reports reach all members on or before February 1st.

The questionnaire has indicated a very large majority in favor of this plan.

Letter-Ballot on Matter for Manual

It has been urged by some that action of the convention on the approval of material for the Manual should be so limited that final action shall be the result of letter-ballot sent to all the members of the Association after the close of the convention. It is suggested that by this means, a better and more deliberate consideration will be obtained than is possible under present methods, because the majority of the Association are not present at annual conventions, and the convention vote may not be representative of the full membership.

The practices of the American Society for Testing Materials and other national organizations of like character are cited as examples of the appropriateness of letter ballot as the best form of final action.

An analysis of the daily registrations at annual conventions of the American Railway Engineering Association indicates that the daily convention attendance is thoroughly representative of the membership. The percentage of corporate members voting by letter-ballot on questions submitted by the American Society of Civil Engineers varies somewhat with the importance of the subject and the efforts made to induce voting, yet the highest number voting on any question in recent years was 45%. As a rule it runs from 18% to 32%.

The following table taken from the records of the American Society for Testing Materials is also indicative of the relative proportions of members voting to total membership:

	Society Membership	*No. of Ballots Returned*	*Percentage of Ballots Returned Per Cent*
1924	3,481	573	16
1925	3,716	414	11
1926	4,000	530	13
1927	4,220	466	11

The average attendance at annual conventions of the American Railway Engineering Association is about 40% of the membership, from which it would appear, that there is a better and more representative attendance of the members in a position to pass on the subjects before the convention, as well as a more reasonable assurance of a larger vote than would be secured if the letter-ballot were employed.

Apart from these and other considerations, it is difficult to understand why the Association as constituted on the Annual Convention should feel constrained to seek the opinion of those who are not willing to spend their time and energy on the floor of the convention and in front of the standing committee making the report, and where it has opportunity of defending the position which it has assumed in presenting the subject to the Association.

It does not appear that there is any justification for a change in the present practice, and the results of the reports and questionnaire fully support this conclusion.

The Manual of Recommended Practice

Representations have been made to the effect that the Manual is not sufficiently interesting, attractive or comprehensive; that it should be prepared in a different manner; and that the material forming its contents should be revised and edited by a staff of paid experts for revision before publication.

The Manual of the American Railway Engineering Association is a unique publication. It is used as a reference book for recommended practice in securing greater efficiency and economy in railway location, construction, maintenance, operation and management. It is used as a standard work on the leading railways of the United States and Canada, and for many of the railways in foreign countries.

The contents of the Manual consist of material reported after long study by the standing and special committees and finally adopted and approved at the annual convention. Its annual revision and correction is the first and most important subject assigned to all standing committees, as being their principal duty. They are expected continually to review the work of their predecessors in the light of modern practice, in order that each succeeding issue may remain consistently up to date and be expressed in the best and most practical manner for the purpose for which it is intended.

There is no publication issued by any national association where the preparation of its material is looked after with any more zealous care than is the Manual of Recommended Practice of this Association.

Considering the purposes for which this Manual is prepared and used, we believe it would be as unwise as it would be impracticable to assign to any supervising corps of persons, expert or otherwise, the task of altering or changing the work of the committee organizations upon whom rests the responsibility for its preparation and revision, as aforesaid.

More Discussion on Convention Floor

More discussion on the floor of the convention is favored by a majority of more than sixty per cent of the replies to questionnaires. One of the principal reasons given for lack of discussion is the short time between the publication of committee reports and the annual convention. As previously stated, this has been largely eliminated this year and should afford an excellent means of determining whether the greater opportunity for studying committee reports will bring about more discussion on the floor of the convention.

A critical review of the communications which have been received on the subject and the studies which we have made of the work of other Associations, causes us to believe that the subject is not generally understood and that many of the expressions concerning the lack of discussion are the result of impressions rather than of mature conclusions.

There has been a tendency to compare meager discussions of recent years with the assumed much fuller discussions of the earlier years of the

Association. It is our view that the development of the committees and their methods have had a great influence upon the discussions at the conventions.

During the earlier years of the Association, the committees started their work in virtually untrodden fields. They had no background of excellent committee work and reports, such as has been the case with committees in the past few years. During this period, the committee reports were largely in the nature of monographs. President Kittredge in his annual report for 1902 states: "efforts have been made to have the reports so handled that they shall truly be reports of committees and not of individuals," and the discussions on the floor are indicative of the practice in this respect that prevailed at that time. Very little had been done in the way of systematizing and disseminating information bearing on the several subjects with which the committees dealt, and, in fact, opinions on many of these subjects were then quite diversified.

Through the succeeding years of the Association's life, committee-work has improved from year to year. Thought over mooted subjects has been crystallized and many varying opinions have been harmonized, so that the tendency towards controversial discussion is much less than it once was, and happily so.

Committees have learned and now quite well understand that thoroughness of investigation and comprehensive presentation of the reports are essential to good committee work. They also realize the futility of attempting to defend reports, the discussion of which on the floor may indicate have not been thoroughly considered, and usually promptly request that the subject be referred back for further study, or readily accept suggestions to that effect. In recent years, discussion of details of diction has been largely eliminated and such matters are left, as they should be, to the Chairman of the committee, who, with the Secretary, edit the reports.

Our experience has been that there is very thorough discussion of the subjects reported upon in the committee meetings before the conclusions reached in the reports are determined upon. The committees are now generally drawn from among best material available in the Association and their reports constitute the results of careful study of the subjects by groups of the most expert men who can be found on the respective subjects. The majority of these men are now thoroughly trained in committee-work. They have the excellent work and example of past committees to draw upon, and there is little wonder that they produce reports which permit of very little discussion. Usually the more thorough the study of these reports, the less will be the tendency to discussion of them.

General

The subjects which have been referred to constitute the principal topics upon which questions have arisen. In addition to these, numerous suggestions on various matters have been received, many of them excellent and

constructive in character, and while important in themselves, they are largely more or less related to the subjects already covered by this inquiry.

These suggestions along with the other information bearing upon this subject of convention procedure consist of three large volumes. They have been catalogued and indexed and will be filed with the Secretary for future reference by the Board of Direction.

Our conclusions and recommendations with respect to changes in practice and procedure of the Association are as follows, and are respectfully referred to the Board of Direction for their consideration:

RECOMMENDATIONS

1. That rules be adopted that will insure Bulletins containing the reports of standing and special committees to be available for the membership on or before February 1 of each year.

2. Except in special cases where it is to the interest of the Association that the Board determine otherwise, reports received by the Secretary after the date determined as necessary to comply with the above rule (1) shall be received as progress reports.

3. Subject to the adoption of rules 1 and 2, and after a suitable interval has elapsed to observe their effect on convention program, the Board should again study the matter to determine what additional means, if any, are desirable, with particular reference to the congestion of program and the promotion of constructive discussion.

4. That in arranging the annual program, reports of standing and special committees shall, as far as practicable, be so grouped that related subjects shall be in logical sequence.

Special Committee on Convention Procedure,

Robert H. Ford, *Chairman;*
G. D. Brooke,
W. D. Faucette,
E. H. Fritch,
C. E. Johnston,
G. J. Ray,
Louis Yager.

PRINTED PAGES OF MONOGRAPHS AND SPECIAL DISCUSSIONS PUBLISHED IN PROCEEDINGS

Years 1900-1928, Inclusive

MONOGRAPHS

Year	Title	Author	Number Printed Pages
1928	The Mississippi Valley Flood—1927	Committee	96
	Freight Train-Curve-Resistance on a One Degree and a Three Degree Curve	E. C. Schmidt	30
	The Highway Grade Crossing Problem	Robt. H. Ford	12
	Boiler Feed Water Studies	Committee	60
	Sink-Head Ingots	R. S. Harden	100
	Traffic Capacity of a Railway	H. Parodi	15
	A Simplified Column Formula of the Secant Type	J. B. Hunley	29
	The Purchase of Materials, Tools, Appliances and Supplies	W. C. Cushing	10
1927	Economics of Railway Tracks	J. M. Farrin	19
	Discussion of Progress Reports on Passenger Stations	J. P. Snow	2
	Starting Points	E. R. Lewis	4
1926	The A.R.E.A.	J. E. Armstrong	8
	Translation of Physical Characteristics	J. L. Campbell	11
	Shrinking of Ballast	H. E. Hale	4
	Water Softening Developments	P. M. LaBach	7
	Stagger of Rail Joints in Tracks and Swaying of Hopper Cars	B. R. Leffler	9
	Effect of Minor Sags and Humps on Operation of Trains	W. L. Webb	7
	Design of Treads—Rolling Lift Bridges	O. E. Hovey	8
1922	Report of American Committee on Electrolysis	Committee Report	176
	The Flat Disk Center for Turntables	B. R. Leffler	7
1921	Note on Rail Inclination	W. C. Cushing	9
	Rail Laying with a Locomotive Crane	W. C. Barrett	5
1920	The New Economy	M. Coburn	6
1919	The New Economy	E. R. Lewis	2
	The Mechanics of Curve Resistances	J. G. Sullivan	11
	Floor Slabs and Flat Top Culverts	Geo. H. Tinker	17
	Service of Cross Ties	P. R. Hicks	52
1918	Screw Spike and Tie Plate Tests	P. R. R. Committee	276
	Design of Docks and Wharves	W. H. Hoyt	25
1917	Final Report of Joint Committee on Concrete and Reinforced Concrete	Committee	64
	Calculating Fuel Consumption	J. G. Sullivan	24
	Power Impact for Movable Bridges	B. R. Leffler	6
	Cost of Railroad Transportation	W. H. Courtney (A. Fink)	40
	Corrosion Test on Iron and Steel	J. L. Campbell	8

Year	Title	Author	Number Printed Pages
1916	Special Steels	W. C. Cushing	194
	Ballast Tampers for Railway Ties	G. W. Vaughan	30
	Rise and Fall, Fuel and Time	C. P. Howard	18
	An Exceptional Flood	J. L. Campbell	6
	System of Standardizing Maintenance of Way Work	Earl Stimson	29
	Test of Douglas Fir Bridge Stringers	H. B. McFarland	188
	Test of Track Bolts and Wrenches	Earl Stimson	16
1915	Recent Development in Track Construction	E. T. Howson	29
	Stresses in Angle Bars	P. M. LaBach	16
	Test of Oregon Fir Piling	H. B. McFarland	103
	Grade Crossing Elimination	C. E. Smith	73
	Freight Trucking Methods and Costs	E. H. Lee	19
	Rail End Connections for Drawbridges	A. J. Hines	15
	The Decision of the Chief Engineer Shall Be Final	C. Frank Allen	16
	Cost of Starting and Stopping Trains	F. W. Green	8
	Rolling Resistance of Cars Over Switches and Frogs	C. L. Eddy	20
	Heavy Locomotive Loading	A. C. Irwin	2
	Results with Use of Screw Spikes	G. J. Ray	63
1914	Grade Reduction Problems	C. P. Howard	28
	Unification of Freight Terminals	G. H. Kimball	18
	Extra Top Width for New Fills	J. C. L. Fish	10
	Valuation of Public Utilities	A.S.C.E. Library	46
	Elimination of Grade Crossings in Cleveland, Ohio	A. J. Hines	60
	The Air Seasoning of Timber	W. H. Kempfer	70
	Rolling Loads on Bridge	J. E. Greiner	32
	Wood Screw and Helical Linings	W. C. Cushing	42
	Bridges, Movable in a Vertical Plane	B. R. Leffler	55
	Notes on L.C.L. Freight House	E. H. Lee	32
1913	Locomotive Fuel Consumption	A. K. Shurtleff	20
	Track Scales	H. T. Porter	6
	History of an Old Iron Bridge	G. K. Lowell	4
	Test of Long-Leaf Pine Bridge Timbers	H. B. McFarland	54
	Bridges Over Navigable Rivers	C. E. Smith	80
	English Track on the P. R. R.	J. T. Richards	33
	Stresses in Track Fastenings	A. J. Hines	7
1912	Design of Bridge Abutments	J. H. Prior	66
	Equated Tonnage Ratings	M. H. Wickhorst	30
	The Storage Battery in Railway Service	L. C. Fritch	41
1910	Protection of Ties from Mechanical Wear	J. W. Kendrick	50
	Tonnage Ratings	Adams & Isaacs	17
	Speed of Freight Trains	Adams & Isaacs	9
	Track Structure—German Railways	W. C. Cushing	43
1909	Stresses in Track Fastenings	W. C. Cushing	25
	The Use of Screw Fastenings	W. C. Cushing	94
		Total	3,078

SPECIAL DISCUSSIONS

1927	Track Recorder for the A. T. & S. F. Ry. Co.	Macomb & Chapman	25
1927	Mechanical Wear on Ties	H. Von Schrenk	6
1916	Nick and Break Test in the Inspection of Steel Rails	Various	11
		Total	42

DISCUSSIONS

DISCUSSION ON STANDARDIZATION

(For Report, see pp. 65-90)

Mr. C. R. Knowles (Illinois Central) :—As Mr. Brumley has told you, the Chairman is unable to be present and has asked me to present the report of the Committee. With your permission I want to take this opportunity of saying a few words in recognition of Mr. W. C. Cushing's long and valuable service to the Association. Mr. Cushing is a Charter Member and is now the sixth member on our rolls. He was a Director from 1906 to 1908 and was President in 1911. He has been a member of the Rail Committee since 1908 and served as Chairman of that Committee in 1913. He has also been a member of the Special Committee on Stresses in Track from 1912 to date, and Chairman of the Standardization Committee since 1926.

In addition to this he has contributed a larger number of monographs of outstanding value to the Association than any other member. Mr. Cushing is not only one of the founders of the Association but has continued to take a very active part in its work throughout the twenty-eight years of its existence, and the growth and success of the Association has been due in no small part to his untiring devotion to the work.

The work done by the Committee on Standardization is of first importance to the Association. It is peculiarly fitting that Mr. Cushing should head this Committee, not only by reason of his ability, but also by reason of the fact that he occupies the position of Engineer of Standards on one of the great railroads of the country. The wisdom of his selection as Chairman of this Committee is evidenced by the results that have been obtained under his leadership.

The report of this Committee appears on page 65 of Bulletin 300, and is divided into two parts, Part 1 covering Recommended Practice and Part 2 National Standardization. Part 1 includes the discussion of Recommended Practice and a comprehensive survey of the extent of the use of A.R.E.A. recommended practices on the railroads in the United States and Canada. Part 2 includes a very complete discussion of National Standardization, particularly in regard to the work of the American Engineering Standards Committee, and a general review of the work of standardization by the Chairman, including comments on world international standardization, and closing with the discussion of the standardization work of the U.S. Department of Commerce.

A survey of the use of A.R.E.A. recommended practices by member roads indicates that they are being widely used; for example, the report shows that probably 70 per cent of the standard plans, specifications and practices on the Missouri Pacific are either A.R.E.A. or closely related thereto.

Information furnished by 47 railroads to the Committee on Ballast indicates the use of their recommended practice on a number of roads. For example, ballast section for gravel is used on 16 roads; ballast section for stone is used on 12 roads, specifications for stone ballast on 17 roads, specifications for washed gravel ballast on 16 roads, and ballast tests on 14 roads.

Perhaps the recommended practices most widely used are those of the Rail Committee. There are a total of 23 railroads represented on this Committee, and the report goes into considerable detail to show the extent of the use of recommended practices on various railroads. It further indicates that while the recommended practices might not be used in detail, they are used as a basis and a general guide for determination of practice wherever conditions permit.

In closing I should like to call particular attention to the policy of procedure on page 66 and read the Foreword to this report on page 65:

"Why is a Committee?"

"But first, what is a committee? A committee is a relatively small number of members of an organization which undertakes to perform a certain service for or on behalf of the whole organization.

"Often a committee appointment is regarded as an honor.

"But it isn't. Committee service is a job.

"Committees are appointed in the confidence that the functions for which the committee was created will be performed faithfully and well. In accepting committee duty, the member gives his virtual promise that he will 'do his stuff.'

"When a committee fails to percolate, it has done a double injury to its organization. It leaves the work undone, in the first place, and stands in the way of anyone else doing the work, in the second place. And to this may be added the blighting effect on the morale of the membership which results whenever the program of the organization is hindered or the obligations of officers and committees treated as of little importance and no binding quality.

"Fellow-members, when you accept official or committee obligation, in heaven's name, make good! Do the job, if possible. If you find that you can't, then step aside and clear the way for someone else.

"To fall down on the job is lamentable; but to lie down on the job is shameful and inexcusable."

It is moved that this report be accepted as information.

The President:—It has been moved and seconded that the report of Committee on Standardization be received as information. The report is now open for discussion.

Are you ready for the question? Those in favor of the motion will say "aye," opposed "no."

(The motion was carried.)

The President:—I hope everyone has read the report of the Standardization Committee from beginning to end. One fine thing about this report is that it shows the extent to which the railroad companies are following the practices recommended by this Association. This is what the Association is working toward, to establish recommended practices that you can use in your daily work.

If you do not wish to ask the members of this Committee any questions, the Committee is excused with the thanks of the Association (Applause.)

DISCUSSION ON UNIFORM GENERAL CONTRACT FORMS

(For Report, see pp. 91-121)

Mr. J. C. Irwin (Boston & Albany—New York Central) :—The beginning of the report is on page 91 of Bulletin 300, and various Sub-Committee reports are on the following pages. This will be handled in detail by the Sub-Committee Chairmen, but your Chairman of this Committee should mention a few features which have influenced the preparation of the reports.

On page 92 on the subject of the Revision of the Manual, two subjects are covered; first, Form of Agreement for Interlocking Plant; and, second, Form of Agreement for Industry Track. In connection with the work on Form of Agreement for Interlocking Plant, that subject was also assigned to Committee VII of the Signal Section of the American Railway Association a year or two ago and after some discussion they presented the A.R.E.A. standard form which has been in the Manual since 1918. However, it was suggested that some changes should be made in that form and that committee was instructed to co-operate with Committee XX of the A.R.E.A. in preparing a new form which they could jointly recommend for adoption.

As a result, the General Chairmen of these committees conferred and the subjects were assigned to sub-committees. Mr. G. E. Beck is Chairman of Committee VII of the American Railway Association, and he assigned the subject to Mr. P. M. Gault, the Sub-Committee Chairman. Committee XX assigned it to Mr. F. L. Nicholson, who will handle the proposed Revision of the Manual under report of Sub-Committee No. 1.

These two committees have met jointly and are now in agreement in recommending the standard form for the A.R.E.A. which will also be recommended by the Signal Section of the A.R.A.

In regard to the Form of Agreement for Industry Track, which you will find beginning on page 102, the form which is now in the Manual was adopted in 1923 after two or three years of discussion and that in itself was a revision of a previous form adopted in 1918. The special reason for reconsideration of this form was the fact that in some features it is hard to get the railroads to agree on the standards and the railroads had a great deal of difficulty in getting industries to agree on some features. The matter was brought up prominently by a Committee of the American Petroleum Institute asking Mr. R. H. Aishton, President of the American Railway Association, if he could not have the American Railway Association adopt a standard form because of the difficulties they had had on account of finding various liability sections in use throughout the country.

Committee XX, when the matter was referred to them, suggested the use of the A.R.E.A. form and it was requested by the American Railway Association to meet the committee of the Petroleum Institute and see what could be done toward satisfying them as to the requirements of the A.R.E.A. form. It was found that the A.R.E.A. form as already adopted did dispose of most of their objections. The objections arose largely from the fact

that A.R.E.A. standards were not used as standard in various parts of the country. At the same time in going over the matter, Committee XX found that there were some sections of the form that could be changed to advantage, making it somewhat clearer to the industry and at the same time not departing from any of the principles which the railroad companies had already adopted.

After a series of meetings of Committee XX, at which in some cases the Committee of the American Petroleum Institute sat in, some revisions were made. These really are of minor importance and practically take out a few things that may hurt in wording, without changing the real meaning. After these meetings were held, the last one in last October, our Committee felt we had gone as far as we could and the American Petroleum Institute asked your Chairman to address their annual meeting here in Chicago in order to help them state to their members and to the public the position of the railways on the subject of industry tracks and the relations between the railroad and the industries in making these agreements.

That was done, and at the present time we think there is nothing more to be done except to act on the recommendations for minor changes made by this Committee in this form.

The proposed change in the liability section should also be mentioned. This Committee now proposes that the liability provision generally known as the "N. I. T. League Clause" be substituted. This provision resulted from conferences between a committee of the Association of Railway Executives and of the National Industrial Traffic League held several years ago.

In the case of agreements covering relations between railways recommended by this Committee and adopted by the convention in recent years, a short arbitration section, which provides for a sole arbitrator, has been used.

This Committee has made an investigation as to what has occurred since that was recommended. We know that a great part of the railroads in the country are already using it, and we have also found that the Association of Railway Executives has done nothing to revise it. Therefore you will find, when the Sub-Committee Chairman makes his report, that this Committee will recommend the use of the so-called N.I.T. League liability section in place of the liability section now in the agreement.

I will ask you to turn back to page 92, the report of the Sub-Committee No. 1 to be presented by F. L. Nicholson, Chairman of the Sub-Committee.

Mr. F. L. Nicholson (Norfolk & Southern) :—The Chairman of Committee XX has called to your attention the procedure adopted by the Committee and also by the Sub-Committee in arriving at its conclusions in reporting revisions to the form of agreement for interlocking plant and the agreement for industry track. Therefore, it remains simply for me to call your attention to these changes.

Kindly refer to Bulletin 300, page 93. For your convenience the Committee has underscored the changes; in the left-hand column is the present wording, and in the right-hand column is the proposed. On page 93 under second whereas, the wording has been changed to read: "The arrangement of the interlocking plant to be as shown on the plan," rather than "being

shown, and the said interlocking plant to be arranged as shown," as now printed in the Manual.

I call attention to an error about the middle of the page, second line above the word "Definition," reading "hereinafter set forth, the parties hereto do covenant," the word "do" was underscored in present form to be omitted and is to be omitted in the proposed form.

Under "Construction," the left-hand column, second paragraph, Section 2, "The cost of removing any existing safety appliances or devices shall be divided in like manner as the maintenance and renewal expense of said appliances or devices has heretofore been divided." This has been transferred to Section 3 (a) under the head of "Apportionment of Cost," where it properly belongs.

Page 94, right-hand column, under "Apportionment of Cost," Section 3 (b), "The cost of constructing, maintaining and renewing said interlocking plant, as shown on Exhibit A, shall be borne by the parties hereto as follows." A space or lines should have been left there for writing the terms.

After a conference with Sub-Committee B of Committee VII of the Signal Section, A.R.A., it was decided to recommend that the following words be inserted as a note: "It is recommended that the A.R.A. Signal Section table of signal and interlocking units be used."

In Sub-Section 3 (d), after the words, "The cost of operating said interlocking plant, including," was added, "the wages of the operators and signal men together with the cost of power, heat, light, and supplies, shall be borne by the parties hereto as follows:

A new paragraph was added under 3 (d) reading: "Any other expenses properly chargeable to operations, shall be borne by the parties hereto in the same proportion as provided for maintenance in paragraph 3 (b)."

"Spare Space," page 95, left-hand column. This is to be omitted. "Extensions and Changes (Section 4). Either party shall have the right to make extensions or changes in said interlocking plant, provided that they shall not (omit the word *materially*) impair the efficiency," omit the words "of the same." Begin a new sentence, "Such extensions or changes, arising from changes made in any existing track or tracks," etc.

On page 96, Section (b), the Committee, after further conference, decided to omit "Each of the parties hereto shall at its own expense keep all switches and derails in its own track free from ice," and substitute the following: "Each of the parties hereto shall, at its own expense, keep all signals, switches, derails and their connections in or about its own track free from ice," etc.

On page 97, the first intent was to have the paragraph read as shown on the present form, but it was later decided to omit "It is further mutually understood that" and begin the paragraph with "Either party may use the operators." This is to conform with the phraseology in the other parts of the contract.

We have inserted after "additional expense," fourteenth line, "Should both parties hereto require additional service, the cost shall be borne by each party in proportion to service rendered."

Under "Material and Labor Supplied by Parties," Section 6, "Each of the parties hereto shall without cost to the other"—we omit the words "without cost to the other." Further down after "Renew them from time to time thereafter; omit the words "likewise, without cost to the other party."

On page 98 underscored, we have added to this paragraph, "However, that work within home signal limits shall be done by plant maintaining party, or under its supervision, at expense of owning company."

With regard to the arbitration clause on page 100, the Chairman of the Committee has spoken to you with reference to this clause. The Committee desires to withdraw its recommendation as printed in Section 10, Bulletin 300, and substitute therefor a shorter arbitration clause providing for one arbitrator. This clause has been adopted for several other forms prepared by the Committee, notably in Bulletin 269, 1924, for trackage rights. Since the printing in the Bulletin the Committee has had a little more time to go over the subject-matter, a little editing has been done which we believe very materially improves the phraseology and gives proper precedence to certain terms that have been in one part of the form stated in a certain order and in another part stated in another order, as illustrated.

On page 99, Liability, Section 9, second paragraph reading: "The party having special charge of the management and operation of said interlocking plant shall not be liable to the other party for the negligent acts or omissions of any person employed in the construction, maintenance, operation or renewal." This same provision written to read in a different way where again used, such as "maintenance, operation, construction or renewal," it has now been written "employed in the construction, maintenance, operation or renewal of said interlocking plant."

The Committee moves the adoption of this form of contract for printing in the Manual, superseding the form now being used.

The President:—It has been moved and seconded that the Form of Agreement for Interlocking Plant be adopted as recommended practice and printed in the Manual. The subject is now open for discussion.

Mr. C. W. Baldridge (Santa Fe):—On page 100, under Arbitration, about a dozen lines down, we find the following provision: "If either party shall fail to choose an arbitrator as herein provided, the arbitrator selected by the other party hereto, at the expiration of ..... days after the date of its said written notice, shall select a second arbitrator, and the two arbitrators so chosen shall select a third arbitrator. If within ..... days after the appointment of a second arbitrator, as herein provided, the two so chosen shall have failed to select a third arbitrator, either party hereto may apply to any judge of the District Court of the United States for the District which shall then include ..... or ....., who shall thereupon appoint the third arbitrator."

I move that the words I just read be stricken out. It is useless to provide for arbitration between two parties when only one party is taking any part in it. It would be necessary to go to court with it anyway, and arbitration made up by one party by itself would not get anywhere. I do not believe that belongs in the proposed form.

Mr. J. C. Irwin:—Mr. President, in regard to arbitration, I think the point is not made clear. The Sub-Committee Chairman thought I had covered that, when really I had not. But while this arbitration section printed on the right-hand side of page 100 is the one that was in the 1918 form, since that time this Committee has given a good deal of attention to the subject, and you probably know that, in our construction contract we omit reference to arbitration altogether, except that we appoint the Chief Engineer the arbitrator. That should be read because this Committee is now recommending that this long arbitration section providing for three arbitrators be withdrawn, and the arbitration section which has already been standardized in recent years by this Association be substituted. This change has been made during the winter meetings, since this form was printed. I shall read that so you will be able to discuss the form which is now being recommended.

In the Agreement for Trackage Rights, the short form resulted from two or three years' discussion in this Committee, and it was especially endorsed by Professor Allen, an expert on contracts, formerly Professor at the Massachusetts Institute of Technology, also a lawyer. This form reads as follows: "In case any question arises under this agreement or concerning the subject-matter thereof, upon which the parties hereto cannot agree, such question may be settled by a sole disinterested arbitrator, to be selected jointly by the parties to this agreement.

"The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as may be determined by the arbitrator." The reason we came to that was the fact that where we had a form of arbitration provision in which one arbitrator is selected by each party and the third is selected by those two, it really results in one man being the arbitrator, at any rate, and the others are usually the advocates for their respective companies.

This Committee has previously recommended and now recommends that we use that short form of arbitration.

Mr. Baldridge, I think we have misled you into discussing one we have already superseded ourselves. What this Committee wishes to recommend now is the arbitration section shown in the Agreement for Joint Use of Freight Terminal Facilities as printed in this same Bulletin 300 at the top of page 112, which is the same as that used in the Agreement for Trackage Rights which is in Supplement to the Manual, Bulletin 267, page 64. It was inconsistent for this Committee to have held to the old section in the Form of Agreement for Interlocking Plant when its report was presented for printing early last Fall.

This Committee in making its recommendations moves, if necessary, that the arbitration section printed at the top of page 112 as Section 14 be used in the Agreement for Interlocking Plant, in place of the one printed on page 100.

Mr. C. W. Baldridge:—Mr. Chairman, I second the motion.

The President:—The question is on the adoption of the form of interlocking plant contract which has been presented by this Committee. Is there any further discussion? Are you ready for the question?

Mr. C. W. Baldridge:—Do I understand the Committee have substituted what is on page 112 for what I have read?

The President:—Yes. Those in favor will say "aye"; opposed "no." The motion is carried.

You may proceed, Mr. Chairman.

Mr. J. C. Irwin:—Continuing the subject Revision of the Manual, on page 102 you will find the Form of Agreement for Industry Track. The recommended changes in this will also be handled by Mr. F. L. Nicholson, Chairman of the Sub-Committee.

Mr. F. L. Nicholson:—On page 102, Bulletin 300, you will find Form of Industry Track Agreement; we have underscored the changes. It is recommended that the paragraph in the present form reading: "Whereas, the operation of cars and engines over said sidetrack at other than the regularly established station facilities of the Railway Company, involves the risk of damage to or destruction of property and injury to or death of persons," be omitted. This is not the place for it. It seems to be objectionable, and under the liability clause these features are taken care of.

The next changes are in the usage clause, Section 5, present reading, first paragraph, "The railway company shall have the right to use, without cost, the whole or any part of said sidetrack for general railway purposes," etc. The recommendation is "The railway company shall have the right to use the whole or any part of said sidetrack, provided such use shall not unreasonably interfere with the use thereof by the industry," omitting the words "without cost," and omitting the words, "for general railway purposes." It seems to be indefinite as to what is meant by general railway purposes; the railways lose nothing by the change.

The second paragraph reads: "The industry shall not permit or authorize the use of said sidetrack by or for the benefit of any other person, firm or corporation not one of the parties hereto, nor assign this contract or any rights thereunder, without the written consent of the railway company."

Change to read: "Neither party hereto shall permit or authorize the use of said sidetrack by or for the benefit of any other person, firm or corporation not one of the parties hereto, without the written consent of the other party." Make a period here and instead of the words "nor assign," begin new sentence. "The industry shall not contract or assign this contract or any rights thereunder, without the written consent of the railway company." That is necessary, of course, to protect the railway company against any change in the management of the industries.

The next change was the liability clause, and when this report was prepared the Committee had not decided on a liability clause. The Chairman of the Committee has outlined to you the reasons why we decided to use the clause corresponding with that of the National Industrial Traffic League, which form was adopted by the Association of Railway Executives. The clause recommended reads as follows:

"It is understood that the movement of railway locomotives involves some risk of fire, and the industry assumes all responsibility for and agrees to indemnify the railway company against loss or damage to property of

the industry or to property upon its premises, regardless of railway negligence, arising from fire caused by locomotives operated by the railway on said sidetrack, or in its vicinity, for the purpose of serving said industry, except to the premises of the railway and to rolling stock belonging to the railway or to others, and to shipments in the course of transportation.

"The industry also agrees to indemnify and hold harmless the railway company for loss, damage or injury from any act or omission of the industry, its employees, or agents, to the person or property of the parties hereto and their employees, and to the person or property of any other person or corporation, while on or about said sidetrack; and if any claim or liability other than from fire shall arise from the joint or concurring negligence of both parties hereto it shall be borne by them equally."

Mr. Chairman, those are all the changes, and the Committee moves the adoption of the proposed form and its printing in the Manual, replacing form now in the Manual.

The President:—It has been moved and seconded that the Form of Industry Track Agreement prepared by the Committee be adopted for recommended practice and published in the Manual.

In this connection, I should call attention to the fact that this contract is very closely associated with the rules of the traffic department of railway companies and it would be proper, before this is printed in the Manual, that conferences be had with the Traffic Division of the American Railway Association and an agreement reached on the terms this Committee has worked out.

Mr. W. C. Bolin (Baltimore & Ohio Chicago Terminal):—I do not gather from the reading of the liability clause whether that fully covers the expense that the railroad might be put to in protecting a private grade crossing. It seems to me that the expense that might be incurred in a private grade crossing outside the right-of-way of the railroad company ought to be provided for.

Mr. J. C. Irwin:—In regard to that, a standardized form possibly cannot cover some things that some companies would like to have covered, and in connection with the construction and maintenance, this form leaves a blank space for the parties to write in what they see fit. The tendency of this Committee has been to put on the industry any expense or liability that is incurred on account of a special service given the industry which is different from that service rendered to shippers on general delivery tracks.

This question of negligence of the company's employees and the question of expense are things that in some cases have not been finally settled, and in the liability section we have thought it best to follow the work of the Association of Railway Executives. They had a special committee appointed for the purpose of conferring with the National Industrial Traffic League on this very thing, and while later on some different section may be developed and approved by the Association of Railway Executives, we think that considering their relations with the public the only thing for this body to do at the present time is to take the liability section which had been approved in that way.

In regard to the expense of crossing at grade, on an industry track, that would be covered by the construction section or maintenance section in any way you see fit in the blank spaces left in that agreement.

The President:—Is there any further discussion? Are there any questions to be asked? Are you ready for the question?

Those in favor of adopting the Form of Industry Track Agreement reported by this Committee with the understanding that this Committee will confer with the Traffic Division of the American Railway Association before publication in the Manual, say "aye"; opposed "no."

(The motion was carried.)

Mr. J. C. Irwin:—On page 106 is Appendix B, report of Sub-Commiteee No. 2. I will ask Mr. E. L. Taylor, Chairman of the Sub-Committee, to make this report.

Mr. E. L. Taylor (New York, New Haven & Hartford):—Sub-Committee No. 2 recommends for adoption the Form of Agreement for Joint Use of Freight Terminal Facilities as amended and as printed in Bulletin 300, beginning on page 106 extending through page 112. I move this form be adopted.

The President:—It has been moved and seconded that the Form of Agreement for Joint Use of Freight Terminal Facilities, appearing on pages 106 to 112, inclusive, be adopted as recommended practice and published in the Manual.

The question is now open for discussion. Have you any questions to ask, gentlemen? Are you ready for the question?

(The motion was put to a vote and carried.)

The President:—You may proceed, Mr. Chairman.

Mr. E. L. Taylor:—The Form of Agreement for Use of Railway Property for Public Highways is printed in Bulletin 293, page 463. This was assigned to our Sub-Committee for further consideration and a quite thorough canvass of the railroad membership of this Association indicated that there seemed to be no general need for the form, and the Committee recommends that this form be dropped from the outline of work.

Mr. President, does that require a motion?

The President:—Yes.

Mr. E. L. Taylor:—I move that form be dropped from the outline of work.

Mr. Robert H. Ford (Rock Island):—The continued development of the Federal-State Highway System as a transportation agency and the tendency of highway authorities to relocate these highways on land originally acquired by the railways for similar use, is becoming a somewhat difficult problem, principally because it is practically impossible for the railroads to say with any degree of certainty how and to what extent in the future much of this property will be necessary for railway use; also, through lack of any recognized plan of co-ordination, it is impossible to know at this time, the proper relationship of the through highways to the railways.

As a general rule, I do not believe it is in the public interest that railway propery be expropriated for highway purposes. On the other hand,

it is often desirable that it may be so used unless and until required for railway purposes.

The Committee will have performed a valuable service if they can present a form, that while permitting reasonable development of the highways, will conserve and protect the rights of railway property for the purpose for which it was acquired.

I trust the Committee will agree to withdraw their request that this subject be dropped.

The President:—The question on the withdrawal of Form of Agreement for Use of Railway Property for Public Highways from the assignment of this Committee is before you. Is there any further discussion?

Mr. E. L. Taylor:—I should like to answer the last speaker, Mr. Ford.

Our Committee gave very careful consideration to the preparation of this form. We really did our work. We prepared the best form that we could under the circumstances. When we sought a definite use for such a form we had quite definite answers and practically all of them were in the negative, that we should not publish or adopt such a form. The reason, as I see it, is that in the construction of a public highway the public funds are being expended and no public board of authority could expend funds under an agreement where recapture by the railroad was possible. In other words, the form takes, rather, that of a permanent leasing or a permanent grant of the right-of-way, and it has been our understanding that where railroads may have, in some cases, obtained a form more favorable to the railroad, such as a lease or a grant with the right to recapture, it probably would not hold because the public funds have been expended.

Mr. Robert H. Ford (Rock Island):—Irrespective of the fact that excessive earnings subject to recapture for most roads is a rather remote probability, the assignment for this Committee is to report upon the best form they are able to devise. If the convention does not agree with the result, they can either adopt it or refer it back to the Committee with the reasons for their action, but until the form is reported, the Committee has not complied with their instructions.

Mr. W. H. Kirkbride (Southern Pacific):—In connection with that matter, I agree with Mr. Ford. It is my own personal observation and understanding that the railroads really need a form of this kind to protect their interests, and I think we are entitled to a submission of a form as a matter of information and progress. I hope the motion will be defeated.

Mr. J. C. Irwin:—I think this Committee does not object to taking that subject back and considering it. They really did prepare such a form, but they came to the conclusion that the form they had prepared really could not be accepted as standard, and therefore their recommendation was to relieve this Association of the burden of trying to find out whether it could be standardized or not, and recommended from their experience that such a form would not be of any particular use.

However, this Committee is willing to withdraw that motion and accept that subject again on its outline of work, if that is the desire of the convention.

The President:—Mr. Taylor, do you withdraw your motion?

Mr. E. L. Taylor:—I am quite willing to do so.

Mr. J. C. Irwin:—I consent to that.

The President:—The question is also withdrawn by the member who seconded the motion.

Mr. E. L. Taylor:—The Committee has reviewed the points in the agreement between companies participating in the Joint Terminal Project as recommended by the Committee printed in Bulletin 294 on page 582. That outline was found to include a complete list of items, no additional items being required.

Our Sub-Committee recommends that this Form of Agreement for Joint Ownership, Use and Management of a Terminal Project be continued in the outline of work for the coming year. I so move.

The President:—It has been moved and seconded that the Form of Agreement for Joint Ownership, Use and Management of a Terminal Project be reassigned. Are you ready for the question?

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I call attention to the fact that it is already included in the assignments.

Mr. J. C. Irwin:—Mr. McDonald is right. We already have our assignment for work for the coming year, and I therefore think it is not necessary to make a motion that it be included except in so far as necessary to change the program already given us.

The President:—It is not contemplated that the program will be changed. We will consider the matter disposed of.

Mr. J. C. Irwin:—On page 113 is the report of Sub-Committee No. 3 on the Form of Construction Contract for Particular Items of Work and on the Form of Cost-Plus Percentage Construction Contract. That will be handled by Mr. Clark Dillenbeck, Chairman of the Sub-Committee.

Mr. Clark Dillenbeck (Reading Company):—You will find the report of the Sub-Committee No. 3 beginning at the top of page 113, Bulletin 300. The first assignment is Form of Construction Contract for Particular Items of Work. Your Sub-Committee has made careful study of this subject and after preparing a tentative form reached the conclusion that such a form of contract would consist of certain parts of the Form of Construction Contract. It was further determined that the form would vary for different items of work and it would be difficult to determine how much or how little of the Form of Construction Contract should be used in preparing such a standard form. That a contract for particular items of work could readily be written by using such parts of the Construction Contract as may be found necessary. It is therefore recommended that this subject be dropped.

The second assignment is Form of Cost-Plus Percentage Construction Contract. We have prepared such a form and it is published in the Bulletin beginning with page 113, and this is submitted for information only.

The President:—Reports of this Sub-Committee are before you. Both are submitted as information. Do you have any questions to ask?

Mr. J. P. Hanley (Illinois Central) :—I would like to call your attention to paragraph 9, Fire Insurance, and bring up the question of possibly extending this paragraph to cover tornado insurance as well as fire insurance.

I recall a case in my own experience where a water tank was shattered by lightning just before it had been taken over from the contractor, and in view of the fact that the contractor did not have insurance to cover this particular kind of hazard, the company was compelled to restore the structure.

It also appears that tornados, lightning and storms are rather prevalent in certain parts of the United States, and I would like to ask the Committee if they have considered putting in a clause to cover such risk.

Mr. J. C. Irwin :—The Committee had not considered that, but I think it is a very good point, and we will be very glad to study it and consider it in our future work.

The President :—Are there any further suggestions, gentlemen?

Mr. C. W. Baldridge :—I notice at the bottom of page 113 the last paragraph of this contract form for cost-plus work. It provides that the contractor shall furnish all materials, etc. It also, at various places in the contract, provides for payment of these materials plus percentages, etc.

It seems to me that the Committee should include, following the words miscellaneous expenses at the top of page 121 and preceding the sub-heading "Payments," as follows: "At the conclusion of the work, all unused materials and supplies shall become the property of the contractor, who shall refund to the company all moneys paid for them plus all percentages allowed thereon."

What I would suggest is a deterrent of the purchase of unnecessary materials on the part of the contractor. If the material that is left over is to belong to the company he will get a percentage on a lot of unused material. If it belongs to him, he probably will not buy any unnecessary material.

Mr. J. C. Irwin :—We are very glad to accept this suggestion of Mr. Baldridge's.

I might say that the Committee itself feels that it is very incomplete and requires a great deal of revision, but it was published in its present form to bring out discussion and to help the Committee in furthering its work.

The President :—Is there any further suggestion?

The understanding is that Form of Construction Contract for Particular Items of Work will be discontinued and that Form of Cost-Plus Percentage Construction Contract will be studied further by the Committee.

If there is no objection, it is so ordered.

Committee XX has done a vast amount of real excellent work this year, and it is excused with the thanks of the Association. (Applause.)

DISCUSSION ON WATER SERVICE

(For Report, see pp. 123-196)

Mr. C. R. Knowles (Illinois Central) :—The Committee has reported on eight of the subjects assigned, four final reports and four progress reports are submitted.

The work of the Committee covers a description of drinking water conditions on railways during the Mississippi Flood of 1927 and methods followed in protecting drinking water supplies during the flood.

Pitting and corrosion of boiler tubes and sheets is discussed in two individual contributions, entitled "Causes of Boiler Pitting and Means of Prevention in Neutral and Alkaline Waters," and "Prevention of Pitting and Corrosion by Electro-Chemical Polarization."

"The Use of Sodium Aluminate on the Rock Island Lines" is also treated in a monograph.

Foaming of Locomotive Boilers, with Special Reference to the Influence of Suspended Matter on Foaming, and Cost of Blowdown is treated comprehensively, and there is an addendum to this subject, entitled "Cost of Blowdown of Locomotive Boilers."

The report includes a description of the relative influence of carbonate and sulphate waters on the operation and maintenance of boilers, together with the comparative cost of purification, substantiating the conclusions of the Committee of 1914, that seven cents at that time, roughly equivalent to thirteen cents at the present time, is a fair measure of the cost of repairs and additional fuel resulting from the scale deposited in boilers by untreated waters.

Another report covers the Types of Hydrants for Coach Yards and General Service and Methods for Supplying Water to Coaches, accompanied by illustrations showing a number of typical installations.

A comprehensive report is submitted covering small service pipes, three inches and under in size. This report deals particularly with the use of prepared joint pipe and copper and brass pipes, and substitutes for wrought iron and wrought steel pipes.

Disposal of Sludge at Water Softening Plants is a problem of constantly increasing importance to railroads operating lime and soda ash plants. The methods commonly used are described and accompanied by layouts showing design of sludge pit and sludge cars.

The Economical Spacing of Water Stations in Connection with Increasing Capacity of Engine Tenders concludes the report.

The first report, appearing under Appendix A on page 125, is merely a reference to the work done by this Committee in connection with the Committee on Rules and Organization, which consisted of the rearrangement of certain subject-matter in the Manual, and the work of the joint committee will be presented in the report of the Committee on Rules and Organization.

Appendix B, page 126, covers the report of the Committee on Drinking Water Supplies. The report of the Committee this year is devoted to a

description of drinking water conditions on railroads during the Mississippi Flood of 1927, and includes a description of methods followed in protecting supplies against pollution and a sterilization of unsafe supplies.

I would like to call attention to a typographical error in the report. Wherever chloride of lime is referred to in connection with the sterilization of drinking water, the words "hypochloride of lime" should be substituted.

Dr. Beach, Chairman of this Sub-Committee, will present the report.

Dr. S. C. Beach (Illinois Central) :—In presenting this report, which appears in Appendix B of Bulletin 300, pages 126 to 130, and covers some of the details of the Mississippi Flood of 1927, I take great pleasure in emphasizing the splendid work done by the railroad companies involved in this unfortunate disaster.

From the beginning to the end of the high water they labored unceasingly to relieve the sufferings of the people and even ran trains when the water was so high as to threaten the firebox on the locomotive.

The newspapers were disposed to treat this as incidental and no particular mention was made of the strenuous efforts put forth by the railroads, without which the loss of life would undoubtedly have been much higher.

Another important act performed by the railroads was the sending of their Engineers and others skilled in water handling out among the marooned people with information and material for sterilization of the drinking water, without which the typhoid and dysentery would have been epidemic.

The President:—If there is no objection, this Sub-Committee's report will be received as information.

Mr. C. R. Knowles:—In the absence of the report by the Sub-Committee on subject No. 3, Pitting and Corrosion of Boiler Tubes and Sheets, monographs have been prepared by Dr. C. H. Koyl and Mr. L. O. Gunderson, members of the Committee. These monographs appear on pages 131, 133 and 135, and give considerable information in regard to practices in arresting the effects of pitting and corrosion in boiler water. These monographs are submitted as information.

Dr. Koyl has given a great deal of thought and study to the subject, and it is due to his energy and industry that we did not fall down completely on the subject of corrosion, and I should like to ask Dr. Koyl to make a few remarks in connection with the subject.

Dr. C. H. Koyl (Chicago, Milwaukee, St. Paul & Pacific) :—These monographs of ours are attempts to establish the truth of the statement that at last we are getting our feet on solid ground in the matter of knowledge of the causes of corrosion.

For long years there was practically nothing known for certain, but after awhile it dawned on someone that iron is never corroded unless it is wet. As no one believed in those days that pure water could affect iron, there followed many studies to learn what there is in water which does affect iron.

But in 1903 a brilliant man at the Massachusetts Institute of Technology proved that the purest iron will dissolve in the purest water. It is not necessary that there should be any contamination in the iron or in the water. The purest iron will dissolve slowly in the purest water.

Then followed the statement and proof that as atoms of iron dissolve in the water there are released from solution, at other points on the metal covered by water, a corresponding number of atoms of hydrogen; and as these atoms of hydrogen gather on the flues of a boiler they gradually build up, in immediate contact with the metal, a thin film or skin which separates the metal from the water.

Everyone knows that if in a boiler there is a thin skin of hard scale on a flue, the flue does not pit under the scale. There are a few exceptions in the case of scale which is itself corrosive at boiler temperature, but in general a scale which is dense enough to separate the flue from the water will thereby protect the flue from pitting. And just in the same manner does the thin film or skin of hydrogen referred to protect the flue from further pitting. It is itself the product of the first solution of iron in the water, but the pitting will stop before any harm is done if only this film of hydrogen can be maintained.

This film would be permanent if it were not for the oxygen of the air which is dissolved in all ordinary water, but the oxygen dissolved in the water combines chemically with the hydrogen, thus destroying the film and the protection to the iron. But it is evident that if we can remove the oxygen from the feed-water before the water reaches the boiler, we can maintain the film and prevent the pitting of the metal.

The first monograph tells the story of the two and one-half years' test of this kind, which has been successful in preventing pitting in that boiler. All we did was to put an "open" feed-water heater on the outside of the boiler to heat the water, and allow its gas to escape through a vent pipe before the water reaches the boiler.

Mr. Gunderson's method is to put an artificial film between the metal and the water, as is shown in the second monograph.

The President:—If there is no objection, the report on Pitting and Corrosion of Boiler Tubes and Sheets will be received as information.

You may proceed, Mr. Chairman.

Mr. C. R. Knowles:—The report of the Committee on Value of Water Treatment and Comparison of Methods appears under Appendix D, page 138. There are also included in this report monographs on the Use of Sodium Aluminate, by P. M. LaBach, and Cost of Blowdown of Locomotive Boilers, by R. A. Tanner. Dr. Koyl, Chairman of this Committee, will present the report.

Dr. C. H. Koyl:—The substances commonly used on railroads for the softening of water are fresh lime and soda ash, but when these alone are used there always remains in the water, in solution or in semi-solution, from one to three grains of carbonate of calcium or carbonate of magnesium. The fraction of one grain which is in semi-solution gives a great deal of

trouble because it comes out of solution slowly during the next few hours and adheres to the pipes or filter sand through which the softened water may be moving; and if heated it comes out rapidly as in the injector of a locomotive.

We have used sulphate of iron, sulphate of alumina, and a few other substances for the reduction of this trouble, and with fair success; but the most efficient of all these substances appears to be the dry sodium aluminate referred to in the paper. We mention it here particularly because its efficiency is due to a very beautiful chemical reaction which was not known to any of us until within the last year. It appears that the alumina from this material combines chemically with the magnesia dissolved in the water when the water treating is nearly completed. Together they form a heavy precipitate, magnesium aluminate, which settles rapidly and clears the water. We do not know of any similar reaction taking place when iron or aluminum sulphate are used.

The President:—If there is no objection, this report on The Value of Water Treatment and Comparison of Methods will be received as information.

Mr. Chairman, you may proceed with your report.

Mr. C. R. Knowles:—This report on the subject of Value of Water Treatment comes under three different headings. The phase of the report dealing with the Foaming of Locomotive Boilers appears on page 143 under Appendix D-1, and in view of the importance of this subject of foaming, I will ask Dr. Koyl to make a few remarks on this Appendix also.

Dr. C. H. Koyl:—For long years there has been a contest between the persons who knew that the presence of sodium salts dissolved in water causes a boiler to foam, and who attributed all foaming tendency to the soda, and the persons on the other side who knew that particles of solid matter suspended in the water in the boiler cause a boiler to foam, and who attributed all foaming to this cause. But, fortunately, within the last few years we have been able to make more exact tests, and we now know that there may be from 2000 to 3000 grains-per-gallon of sodium salts in the water in a stationary boiler without foaming, if there is no matter in suspension. And we know also that there may be considerable matter in suspension in the boiler without foaming, if the water is free from sodium salts.

Most important of all is the establishment of the method of interaction of these substances to produce foaming. If the water in a boiler is practically pure, that is, if the water is free from sodium salts in solution and from particles of solid matter in suspension, then when a steam bubble comes up through the water it breaks at the surface of the water, leaving behind the thin skin of water which surrounded it and itself passing to the steam pipe very nearly dry. If the water contains only a moderate amount of sodium salts in solution, say 40 grains-per-gallon, the bubbles break in nearly the same manner. But if the water contains the 40 grains-per-gallon of sodium salts in solution and also 40 grains-per-gallon of matter

in suspension, then as the steam bubble rises through the water it gathers to its skin of water the suspended particles in its path, and these particles appear to strengthen the skin of water so that the bubble does not break at the surface of the boiler water but is often carried to the steam pipe before it breaks. This produces wet steam and is what is known on a railroad as "foaming." The reason why castor oil added to boiler water is effective in preventing foaming is that the tiny oil drops attract the particles of solid matter more strongly than does the water, and this keeps the steam bubbles free from specks so that they break easily and do not cause wet steam.

We derive this knowledge principally from the extensive and careful work of Professor C. W. Foulk, of the University of Ohio. And while I am at it I should like to call attention to the fact that in our Manual of 1921 (that is a long time ago as these studies go) there is a statement of about one-half the information given above, which was put into the Manual in those early days by Mr. R. C. Bardwell, who sits to my right, and who must have had a stroke of genius when he put it in, because I doubt that there were five persons in the world who knew the facts at that time.

The President:—No objection, this phase of the report will be received as information. You may proceed, Mr. Chairman.

Mr. C. R. Knowles:—The final section of this report on the Value of Water Treatment appears on page 156, under Appendix D-2. I will not impose on Dr. Koyl and have him tell us all about sulphate and carbonate scales, but will merely say that the finding of the Committee in discussing this particular subject, in which they were given a great deal of assistance by Mr. Chorley, of the Pennsylvania, developed that the work of the Water Service Committee in 1914 was really classic, in that the figures arrived at for the value of scale removal in locomotive boilers still are good to-day. The Committee and others as well have been trying to pick holes in the report the Committee made fourteen years ago. It shows that the figures have stood up under the fire of the guns for all these years.

The President:—You may proceed, Mr. Chairman.

Mr. C. R. Knowles:—The report on Types of Hydrants for Coach Yards and General Service and Methods for Supplying Water to Coaches appears on page 158 under Appendix E. Mr. J. H. Davidson, Chairman of that Sub-Committee, will present the report.

Mr. J. H. Davidson (Missouri-Kansas-Texas):—In presenting this report we have shown types of hydrants, hydrant valves and accessories that have been given severe service tests, and when properly installed, these hydrants and the hydrant valves will do away with a considerable waste of water, which is evident with a great many hydrant installations now in this service. They will also serve to protect the water from pollution at the hydrants, and will also be found satisfactory in respect to safety.

In the matter of conveying the water from the hydrants to the coaches, your Committee has found that it was practically impossible to design a

device that would protect the ends of the hose against pollution, because so far we have not been able to get hold of any device which cannot be rendered almost useless by improper and careless handling. However, we find that they do have this virtue, they call the attention of the men entrusted with this work to the necessity of taking some precautions in protecting the drinking water supply against pollution.

We show on pages 172 and 173 some suggested devices for protecting the nozzles. You will note from our conclusions that we feel the greatest good in this respect can be accomplished by impressing upon the men who are entrusted with this work the necessity of better and more careful handling of the hose and other accessories.

The President:—If there is no objection, the report of this Sub-Committee on Types of Hydrants for Coach Yards and General Service and Methods for Supplying Water to Coaches, will be received as information.

You may proceed, Mr. Chairman.

Mr. C. R. Knowles:—The next report of the Committee appears on page 177 under Appendix F—Pipe for Service Lines Three Inches and Under in Size, with Particular Reference to the Use of Prepared Joint Cast Iron Pipe and Copper and Brass Pipe as Substitutes for Steel and Wrought Iron Pipe. This report will be presented by Mr. J. P. Hanley, Chairman of the Sub-Committee.

Mr. J. P. Hanley (Illinois Central):—As stated by Mr. Knowles, this report appears on page 177 and the Sub-Committee divided the subject into several sub-divisions.

We first assumed that a service pipe is the one used in conveying water from the distribution system to a particular building for facility, and the report is intended to cover this class of pipe only.

We also sent questionnaires to many railroads and cities to obtain information on the kinds of pipe that they used in their work. We refer to this on page 177 under Municipal Practice.

On page 178 we mention the kinds of pipe used, after which we briefly discuss the merits and demerits of the various kinds of pipe such as galvanized iron and steel, lead service pipe, brass service pipe, copper service pipe, standard bell and spigot cast iron pipe, screwed joint cast iron service pipe, pre-calked joint cast iron service pipe, bolted joint cast iron service pipe, and after that we discuss pipe linings and coatings, which are sometimes necessary in case the pipe is laid in corrosive soils or intended to handle corrosive water.

On page 181 we indicate at some length the present practice of railroads and cities, which includes detailed information or answers received to our questionnaires.

On page 173 we show the approximate cost per hundred feet of the various kinds of pipe considered.

On page 183 we also show a bibliography covering previous reports on this subject. Many reports on this subject have been issued by the United States Bureau of Standards, American Society of Mechanical Engi-

neers, Engineering News-Record, National Research Council, American Water Works Association, American Railway Engineering Association, American Society for Testing Materials, and the American Foundrymen's Association.

On page 185 we show conclusions which boil down the subject as briefly as possible and put it out in such a way that people who have not the time to read the entire report will probably obtain interesting information by reading the conclusions.

Mr. C. R. Knowles:—It is moved that this final report be accepted as information and that the conclusions on page 185 be adopted for publication in the Manual.

The President:—It has been moved and seconded that the body of the report be received as information and that the conclusions printed on pages 185 and 186 be adopted as recommended practice and published in the Manual.

The question is now open for discussion. Do any of you gentlemen wish to discuss these conclusions? Are you ready for the question? Those in favor will say "aye," opposed "no."

(The motion was carried.)

Mr. C. R. Knowles:—The next report of the Committee is on the disposal of sludge at water softening plants appearing on page 187. The report will be made by Mr. R. E. Coughlan, Chairman of the Sub-Committee.

Mr. R. E. Coughlan (Chicago & Northwestern):—The disposal of sludge at water softening plants is more or less of a nuisance. We do not want it and nobody else seems to want it. In many cases it is almost a menace, as many of the cities will not allow it to be put into the sewers and farmers often object if it gets on their land.

In an endeavor to find some way to dispose of it we canvassed all of the railroads which operate lime and soda ash softening plants, as well as many of the municipalities in this country and Canada.

On analysis this material consists principally of calcium carbonate. When it comes out of the plant it contains 80 to 90 per cent water. We pile it in piles or put it into a pit and allow it to accumulate or dry out. The only possible way to get rid of it is to induce the farmers to haul it away.

It is an excellent antidote for sour land but the trouble has been that the present farm machinery will not handle it as a fertilizer. If any compensation is asked for it, the farmers find that they can buy regular powdered limestone for a lower price than it costs to load the sludge.

After canvassing all of the methods of disposal we find that the most economical method is to allow it to drain out onto low land or into a moving stream. If the plant is so situated that it is impossible to do this, pits must be constructed to retain the sludge until such time as the pits are cleaned with a clam shell or other method.

In our report we show one of these pits, also a sludge car in use on one of the Southwestern railroads. On page 193 we show piles of this sludge awaiting a natural disposal.

The Committee has found one city that reburned the sludge to convert it back to calcium oxide. This method is unsatisfactory, as the product is of poorer quality than the original chemical. It cost more to return it than to buy new chemical. A little can be used as a filler for whitewash and a little used in the manufacture of chalk and toothpaste, but the present raw material is more satisfactory and cheaper than the sludge.

The Committee recommends that the best method of disposal of this sludge is to allow it to drain out of the plant onto low ground or into a moving body of water. Where this is not possible, every effort should be made to interest agricultural agents in a campaign to educate the farmers to use it as a fertilizer or antidote for sour land.

The President:—The report on Disposal of Sludge at Water Softening Plants is presented to you as information. Has anyone any suggestions to make? If there are none, it is so ordered.

Mr. C. R. Knowles:—The next and final report of the Committee appears on page 194 as Appendix K, Economical Spacing of Water Stations in Connection with Increasing Capacity of Engine Tenders. This report will be made by Mr. R. C. Bardwell, Vice-Chairman and Chairman of the Sub-Committee.

Mr. R. C. Bardwell (Chesapeake & Ohio):—Our study has developed that the economical spacing of water stations in connection with the increasing capacity of engine tenders, report of which appears in Bulletin 300 on pages 194 to 196, inclusive, is a question of special study for the individual districts under consideration in order to provide maximum acceleration of train movement consistent with local conditions and traffic requirements by the elimination of unnecessary stops for water which not only delay the trains in question but also retard the progress of following traffic.

The various factors which influence the economies possible from the development of this study are enumerated, such as saving in train overtime, increase in gross ton miles per train hour, saving in fuel, train crew wages where they are affected by overtime, train supplies, and repairs and depreciation of equipment. Against this expense must be balanced the additional costs for hauling the added weight. These factors are subject to calculation by generally recognized satisfactory methods and we do not feel that general conclusions can be drawn. The various factors must be applied to the individual district under consideration, and we are therefore submitting this report to the Association as information.

Mr. C. R. Knowles:—That concludes our report.

The President:—Have any of you gentlemen any questions to ask this Committee or any suggestions to make with reference to the work this year?

Mr. J. M. Farrin (Illinois Central):—Down at the lower part of page 194 it says that the approximate coal waste will average about one-half ton per stop. I think this twice too much. I think it will average about 500 lb.

Mr. R. C. Bardwell:—The figures which were used in connection with the hypothetical example were the results of actual tests made in the field. These tests have shown that the waste of fuel will be more in some cases than in others, but we feel that the illustration used is conservative.

It is true there will be many cases where the loss in fuel will not reach the figure shown, but again there will be other cases, especially where heavy tonnage is being handled under adverse weather conditions, where the fuel waste will be considerably more. The illustration used is considered to be a fair average.

Mr. J. M. Farrin:—I still think one-half ton is wrong. I am giving my information from actual tests and I know that a half ton is too much coal. In fact, 400 lb. would be a better average than even the 500 that I suggested.

Mr. C. R. Knowles:—What tonnage train?

Mr. J. M. Farrin:—I am talking about the average train.

Mr. C. R. Knowles:—You mean an average tonnage.

Mr. J. M. Farrin:—The average train, say 3500 tons, will consume between 400 and 500 lb. of coal in making a stop.

Mr. C. R. Knowles:—The Committee in this connection, I happen to know, were dealing with trains of 10,000 tonnage.

Mr. J. M. Farrin:—There are very few trains of 10,000 tons being run in the United States, and that is not the average train to-day.

Mr. J. M. Metcalf (Missouri-Kansas-Texas):—It seems to me that the Committee has perhaps not exhausted the possibilities of study on this subject, which may produce information of value. While it is true that the problem is one which varies with conditions and requirements, is it not possible to give us something more definite as to what the problem is and how we should go to work to solve it? How much work on the average should a locomotive do on a 10,000-gallon tank of water? To what extent does the consumption of water vary with gradient, with tonnage hauled, with stops made?

For given conditions and comparing tanks of different capacities, how may the safe and economical spacing of water stations be determined, giving proper weight to cost of stopping trains, of constructing, maintaining and operating the water stations, and of installing, transporting and maintaining locomotive tenders? We ought to know these things, but many of us do not, and it would seem that the Committee may be able to give us more light on the subject. A practical example of the solution of such a problem, even though it might not fit our particular case, would give us a more definite line on how the solution should be undertaken. I believe there is room for a substantial saving on many roads to result from the use of the larger tender tanks, through elimination of extra train stops, or even of water stations which are located where they are just because they have always been there, and I believe this Committee can give us some more definite outline of the method for determining where that is the case. I should like to see the subject continued.

Mr. Louis Yager (Northern Pacific):—Speaking for the Outline of Work Committee, we have just realized the major portion of this committee assignment involves economics of railway operation. The discussion brought out by Mr. Farrin indicates that very clearly. That is the line of work that his Committee has been doing and we are making the suggestion, Mr. President, in the reassignment of this subject we will ask for very close co-operation with Mr. Farrin's Committee.

The President:—The Committee on Outline of Work will take these matters under consideration. Have you anything further to report, Mr. Chairman?

Mr. C. R. Knowles:—Nothing. That concludes our report, Mr. President.

The President:—The Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON TIES

(For Report, see pp. 197-254)

(Vice-President Louis Yager in the Chair.)

Vice-President Yager:—In the absence of the Chairman and the Vice-Chairman of the Tie Committee, the report will be presented by Mr. R. S. Belcher.

Mr. R. S. Belcher (Santa Fe):—I am sorry Mr. Burton can not be here today. I am sure that the presentation of the report would be a great deal improved if he were here to present it instead of the present Acting Chairman.

The report will be found in Bulletin 301, page 197. The Committee is reporting on six subjects: the first, that of Anti-Splitting Devices, will be presented by Mr. E. L. Crugar.

Mr. E. L. Crugar (Illinois Central):—The report of the Sub-Committee on Anti-Splitting Devices will be found on page 199, Bulletin 301.

We have not as yet completed our investigation along this line and the information contained in this Bulletin is presented merely as information. We hope to be able at a later date to give more definite information.

Vice-President Yager:—The Sub-Committee has presented some very interesting information in connection with this subject. Are there any members who wish to make any inquiries of the Sub-Committee? If not, the report will be received as information.

Mr. R. S. Belcher:—The next subject, Size of Hole for Pre-Boring, is reported in Appendix B, page 209.

Last year's report gave results of a canvass of those railroads pre-boring their ties, which showed the majority boring holes one-sixteenth inch less than the diameter of spikes in hardwood and one-eighth inch less in softwood. This year the report covers extensive laboratory tests made by Mr. E. E. Chapman, Engineer of Tests of the Santa Fe, whose co-operation the Committee feel they were very fortunate to secure.

The pictures on pages 212 to 229 show strikingly the wood fiber distortion caused by the spike, greatest where no holes or small holes are bored and least where spikes are driven in holes $\frac{7}{16}$ inch or more in diameter. A study of these results, together with the distortion of wood fiber as shown by the pictures, has led to the recommendations on page 246, that holes for cut spikes in hardwoods be $\frac{1}{16}$ inch smaller than the spike, and that holes for cut spikes in softwoods be $\frac{1}{8}$ inch smaller than the spike. The Committee recommended that additional study be made of the type of spike point for use in pre-bored ties, as the tests covered by this report indicate the chisel-point spike is not entirely satisfactory, the sharp corners leading away from the bored hole.

This report is presented as information, and it is moved that the recommendations be adopted for the Manual.

Vice-President Yager:—It has been moved and seconded that the recommendations submitted at the bottom of page 246 be approved and included in the Manual.

Mr. A. Montzheimer (Elgin, Joliet and Eastern) :—Have the Committee considered the necessity of putting those conclusions in the Manual? It seems necessary to include the conclusions at the bottom of page 246.

Mr. R. S. Belcher:—It was not the intention to include the conclusions in the Manual, merely the two recommendations given at the end of the report on page 246, Recommendations 1 and 2.

Vice-President Yager:—The Committee have done a very exhaustive piece of work in tests which they have conducted and it seems to us that there ought to arise a number of questions that might be put to the Committee.

Mr. C. W. Baldridge (Santa Fe) :—I think the Committee is altogether too modest in not including the conclusions as part of the matter to be inserted in the Manual. I would like to amend their motion to include the conclusions and recommendations at the bottom of page 246 for inclusion in the Manual.

Mr. C. C. Cook (Baltimore & Ohio) :—I think the conclusions are in error if they are based upon the data given in the table. I refer to Conclusion No. 3. It says, "For hardwood ties, the greatest resistance to withdrawal results with a hole slightly smaller than the largest." If you will look at the tablae on page 239, which shows the resistance to pull, I do not believe you will find any figures that support that.

As I understand it, the reason for the two recommendations given is that the Committee felt there was a damage to the fiber of the wood as exhibited by the views which precede these tables. That combined with the conclusions was the basis for their recommendations, but the conclusions themselves, if they are based on these tests, would be unconvincing in support of the recommendations.

Mr. R. S. Belcher:—I am glad Mr. Cook brought up that point. I had intended to mention it.

The recommendations are perhaps not entirely in accord with the bare figures of the test as to the resistance to withdrawal of spikes and the resistance to horizontal thrust, but when we consider the distortion of wood fiber as shown by the pictures, which are also a part of this report, and the fact that in driving the spikes for this test it was difficult to make the spikes follow the bored holes, particularly in the ¼ inch holes and ⅜ inch. These sizes are deemed too small for practical use with either $\frac{9}{16}$ or ⅝ inch cut spikes.

A study of the data with this in mind seems to show the correct size of hole for maximum pull in hardwoods to be $\frac{7}{16}$ for $\frac{9}{16}$ spikes and ½ inch for ⅝; for softwoods, $\frac{7}{16}$ inch diameter gives the maximum pull for both $\frac{9}{16}$ and ⅝ spikes.

A study of the data on resistance to horizontal thrust indicates from $\frac{9}{16}$ inch spike a $\frac{9}{16}$ inch hole has the highest load at the yield point, for both hard and softwoods. For the ⅝ inch spike the ⅝ inch hole takes the highest load in the hardwoods and there is practically no difference with the half inch, $\frac{9}{16}$ and ⅝ holes in the softwoods, as shown in Table 5. Does that answer your question, Mr. Cook?

Mr. C. C. Cook:—Yes, that answers my question.

I would like to add a remark drawn from some observations I have made in boring plants: The custom today is to use a 3/8 and 7/16 inch hole, and these recommendations are going to require those users to increase the size of their holes. I am perfectly willing to accept the Committee's recommendations on the basis of the study they have given the subject, but those who are now operating boring plants may question the wisdom of increasing the size of holes as recommended.

Mr. W. P. Wiltsee (Norfolk & Western):—I would like to ask the Committee why they recommend 1/16 inch less diameter for the spike in hardwood. Their diagrams show that running from 1/4 inch hole, which we will agree is too small, they get the least resistance to pulling, with the 5/8 spike. Why would not the 1/2 inch hole give greater resistance to pulling and still meet their objections as to smallness?

Mr. R. S. Belcher:—I do not believe that I quite got the question, Mr. Wiltsee. Will you repeat part of that?

Mr. W. P. Wiltsee:—On page 233, your diagram shows that with the smaller hole you get greater resistance to the spike in pulling. In your recommendations you say 1/16 inch smaller than the diameter of the spike. With a 5/8 spike you could still use 1/8 inch less hole, and have 1/2 inch size hole which would still be larger than your minimum.

You say in your conclusions that 1/4 and 3/8 inch holes are too small for practicable purposes. Therefore, why would not 1/2 inch hole with a 5/8 inch spike give greater resistance and meet your other objections?

Mr. R. S. Belcher:—There is some advantage in the resistance to side thrust in the larger size of hole. For a 5/8 spike the resistance to side thrust is greater with a 5/8 hole. In a pulling test the resistance to pull is greater with some of the smaller sizes. The tendency of the spike to lead away from the bored hole is greater with the smaller sizes of holes. The distortion of the wood fiber is greater in the smaller sizes of hole. All those things have to be considered in arriving at the standard size hole which we should adopt, and it seems to me we should give a certain amount of consideration to the fact that the horizontal resistance to horizontal thrust is greater with the larger size hole. That was the reason for trying to strike what we might call a happy medium in the size hole to be standard for certain sizes of spikes; in other words, the recommendations as given by the report.

Mr. L. H. Geddes (Greenlee Bros. & Co.):—Further referring to Mr. Cook's remark, the reason for the bored hole is to get away from the breaking down of fibers; in boring a 3/8 inch hole using the 9/16 inch spike, you are still breaking down a certain amount of fiber, so in the softwood or coarse fiber ties, the larger the hole, the less breaking down of the fiber.

I should like to illustrate this with the two index fingers. If you point the first joints down, it will give you an illustration of what happens to the fiber when you drive the 9/16 inch spike into a small hole. Naturally, when you pull against the tilted fingers, you have a greater pulling resistance, but you also have a great deal less resistance against horizontal side thrust.

I think if you will strike a happy medium of side thrust and pulling power, it will give you the greatest amount of actual holding power of the spike in the tie over an extended service period. The pull is not a fair test immediately after the spike has been driven, because there has been no side thrust applied, which in the case of the broken down fibers greatly reduces the holding power of the spike, and I therefore think that the fair test would be applied to spikes which have been in service where the holes have been subject to considerable side thrust.

Mr. J. M. Farrin (Illinois Central):—It seems to me in looking over these conclusions and the recommendations, that they are not definite and explicit. No. 3 says, "For hardwood ties, the greatest resistance to withdrawal results with a hole slightly smaller than the largest."

Mr. R. S. Belcher:—Than the largest size hole tested.

Mr. J. M. Farrin:—I think you should state what you mean and not leave it to us to draw our own conclusions.

No. 1 in the recommendations says, "That holes for cut spikes in hardwoods be $\frac{1}{16}$ inch smaller than the diameter of the spike." What is the diameter of a spike? I always thought spikes were square except a screw spike.

Mr. R. S. Belcher:—We do have some round spikes but they were not considered in making these tests.

We are willing to change that to "size of spike," if that will be better. In Conclusion No. 3 we might say, "Slightly smaller than the spike." I think that is a misprint. I really had not noticed that before.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—While you are on the subject of conclusions, I think possibly some revision in Nos. 4 and 5 might be in order. No. 4 concludes that a ¼ inch and ⅜ holes are too small for use with chisel-pointed spikes. No. 5 goes on to say chisel-pointed spikes are not satisfactory for driving in the hole. Does the Committee mean that we ought to abandon the chisel-pointed spikes? It seems to me that is the logic of those two conclusions.

Vice-President Yager:—It is the purpose of the Committee to study further the best design of spike, that is, the cutting edge. That is part of the work for the ensuing year.

Is there any further discussion? There is an amendment before the house. It has been moved and seconded that the conclusions given, Nos. 1 to 5, as corrected by the Chairman of the Committee, be included with the recommendations in the matter for the Manual. Are you ready for the question?

Mr. C. C. Cook:—Would a further amendment be in order? If the conclusions are included there should be included some of the diagrams; otherwise they would be inharmonious with the recommendations. I would move you that those diagrams indicating the destruction of the wood fiber, which along with the conclusions support the recommendations, be also included.

Mr. C. W. Baldridge:—The rules as I understand them are intended to make the matter that goes in the Manual as brief as possible, and wherever

anything appears in the Manual a reference is given to the Proceedings which brought about the adoption of those conclusions and all of the matter that is published in this Committee report will be in the Proceedings and there will be a reference in the Manual, no matter what part of it is put in the Manual, to the place where this came from. Anybody who wants to know the details is supposed to go to the Proceedings to get it.

Mr. G. D. Brooke (Chesapeake & Ohio) :—As far as I can recall, this is the first time a motion has been made on the floor of a convention to place matter in the Manual that was not recommended by the Committee. I am in sympathy with the idea that some conclusions of the nature of those appearing just before the recommendations should go into the Manual, but I do not believe they should go in the Manual until this Committee has recommended them.

Mr. Robert H. Ford (Rock Island) :—I agree with the previous speaker. In the light of this discussion, perhaps the Committee will be willing to withdraw the subject for further study in order that the Association may have the benefit of their conclusions for ultimate adoption for the Manual.

I believe it is contrary to the established practice of this Association to materially modify the reports of the standing committees from the floor of the convention and then adopt the result for printing in the Manual as recommended practice. If upon presentation, the convention feels that a report shows evidence of being incomplete or improperly developed, or that the conclusions are not properly justified, established practice requires that the reports should be referred back to the Committee for further study, etc.

This discussion has evidenced quite clearly that it would be well for the Committee to give the matter further study and make a further presentation and I hope that they will consider the desirability of withdrawing their recommendation in order that the subject may be given further study during the year.

Mr. R. S. Belcher :—We accept that recommendation.

Vice-President Yager :—The motion is withdrawn and the second also. Does anybody want to be heard? It is understood that this very interesting subject will be continued for another year with the hope that it will be brought to a definite conclusion. You may proceed, Mr. Chairman.

Mr. R. S. Belcher :—The next report, Appendix C, on page 247, makes recommendation as to Renewals of Switch Ties, and will be presented by Mr. W. C. Bolin.

Mr. W. C. Bolin (Baltimore & Ohio Chicago Terminal) :—The Sub-Committee last year presented a report on the result of the questionnaire submitted to a representative number of railroads.

That questionnaire indicated about sixty per cent of the roads favored individual renewal of switch ties and about forty per cent favored renewal of switch ties out of face. This year the Committee has considered further the results of that questionnaire and on the basis of the information before them we make a recommendation as printed on page 247 that the switch ties should be renewed individually. We recommend that this be received this year as information and if no material objections are received,

at our following convention next year, a recommendation will be made for adoption and publication in the Manual.

Since we submitted this report, we have received one criticism. I do not see Mr. C. A. Morse, our Past-President, in the room, so I will read his criticism for the benefit of the convention.

"I have just read Appendix C of Committee on Ties in Volume 29, No. 301, of the Bulletin of the A.R.E.A.

"This Appendix C attempts to deal with the question of economy of two methods of renewing switch ties—one renewing them out of face, and second, renewing them piece-meal.

"As I read the report it strikes me that the Committee who made up this Appendix C were not familiar with the method ordinarily used in renewing ties out of face.

"In the fourth paragraph they say, 'Under this method needed renewals might be postponed until the end of the fifteenth year, etc.' Anybody that knows anything about renewal of switch ties out of face knows that no such idea is carried out. If for any reason any ties need renewal it is the practice in the case of renewal to a face to renew those ties and to keep the ties in the set in first-class condition all the time. There will ultimately, however, come a time when fifty per cent or more of the ties need renewal at once and it is at that time when it is the practice of roads that renew switch ties to a face to renew the entire set.

"Another thing that I do not consider correct in this report is a statement that the labor cost of applying the average tie in a No. 10 set by individual renewals is $1.00. This is entirely too low. I doubt any gang renewing the average switch tie for less than $1.50.

"Where ties are renewed individually in a set of switch ties you get a bad riding track for the reason that you put in a solid hard tie while on either side of it you have ties that have been weathered and softened until this new tie gives a different feeling as you ride over it.

"The main object in renewing ties to a face is to maintain a good riding track through the switch and frog, the place where you need the best track conditions of any place on the road.

"By renewing the ties to a face you get a first-class riding track and if your rails are all plated, as they should be, the necessity for individual tie renewals in that set does not often arise other than perhaps under the frog itself.

"In my opinion, it will be found that out of the twenty-eight roads canvassed that the twelve roads that recommend the individual method of renewal have never tried the renewal to a face method.

"The statement in the report to the effect that ties taken out when the ties are renewed to a face are not utilized is wrong, as every tie that is taken out can be used either in a set of switch ties on some branch or in many cases in main line turnouts, and any that are not fit for this purpose are usable as track ties in yards and sidings. Therefore the statement of a loss in material of $63.40 in their example is not a fact.

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"I think it is very unfortunate that a subject of this kind should be handled by a Committee who apparently has had no experience in renewing switch ties to a face.

"Personally I have been familiar with this subject for the past twenty years. It was analyzed carefully on the Santa Fe, and it was decided that the economical method, and the method which gave the best riding track through switches, was the renewal to a face method.

"When I came to the Rock Island they were renewing individual switch ties and I changed the method to renewal to a face and we have been following that method for the past thirteen or fourteen years with the result that we have first-class track through our turnouts, which was something that they never had when they renewed the ties individually."

The Committee welcomes any criticism on this subject and within the time limit that we have we would appreciate any comments.

Vice-President Yager:—Are there any other suggestions to the Sub-Committee on this subject?

Mr. C. W. Baldridge:—I believe that the question of renewing switch ties out of face requires conditions. On the heaviest main track territory it is probably true that it is advisable to renew switch ties out of face. On lighter main lines and all branch lines and sidings and yard tracks, I do not believe that it is advisable to renew switch ties out of face.

The theory is of course that the ties that are still usable will be re-used somewhere else, but it does not work out in a great many cases.

I have seen switches in tracks leading to a ballast pit used only two or three months out of a year being renewed out of face, new treated ties being put in that kind of track. I do not know where they intended to use the second-hand ties. I know where they did use them—they used them in the wood pile.

Vice-President Yager:—The Sub-Committee hopes to get more of just such interesting criticisms and comments. With that understanding the work of the Sub-Committee will be received as information.

Mr. R. S. Belcher:—The next is that of Substitute Ties, on page 248.

There is no one of the Sub-Committee present, I believe. I might say this report is in line with those which have been furnished for a number of years by the Tie Committee. It begins on page 248, and on page 252 is a tabulation of tests of substitute ties now in progress. This report is submitted as information with the recommendation that the subject be continued.

Vice-President Yager:—This is in line with the previous practice and the effort of the Sub-Committee is to keep the Association informed concerning the data on substitute ties. It will be received as information.

Mr. R. S. Belcher:—On page 253, Appendix E, "Develop and Recommend a Traffic Unit for Use in Comparing Cross-Tie Life." This subject will be presented by Mr. A. F. Maischaider, Chairman of the Sub-Committee.

Mr. A. F. Maischaider (Cleveland, Cincinnati, Chicago & St. Louis):—This subject is presented just as information to the convention. I want to

call attention to an error about half way down on page 253. It says this unit is derived by dividing the total annual equated gross ton miles by 365 and multiplying by the equated miles of track maintained. This should read, "This unit is derived by dividing the total annual equated gross ton miles by 365, multiplied by the equated miles of track maintained." That is, the divisor is 365 times the equated miles of track maintained.

As I said before, this is given as information.

Vice-President Yager:—Is there any discussion on this?

Mr. H. C. Crowell (Pennsylvania):—I have three points I would like to take up with the Sub-Committee. The first two have to do with the method of deriving this traffic unit and the third has to do with the use of the traffic unit after you get it.

Under the head of method of deriving the traffic unit, I would like to invite the Committee's attention to the fact that on page 918 of the Proceedings for 1925, Committee XXI gave a method or a formula for equating traffic. This formula, by the way, is the famous Yager formula promulgated by the United States Railroad Administration, and after considerable thought was adopted by Committee XXI as being the best method for equating traffic. The difference between that method, and the one here described is as follows: The Yager formula, or Committee XXI formula, has as its factors one, two and three, one representing the freight and passenger gross ton miles, two being applied to freight locomotive ton miles and three as the multiplier for the passenger locomotive ton miles. The formula in the Tie Committee's report is one, two and one-half. Before the Committee disregards the formula that is already in the Proceedings and in the Manual, I think they should show why the ratio one, two and one-half, is better than the combination one, two and three.

Secondly, under the head of method of deriving the traffic unit, I wish to invite your attention to the fact that you will not get proper results by using the equated track miles shown at bottom of page 253. These equated track miles maintained are supposed to be taken from Item 1-D in the I.C.C. comparative statement of operating averages. If you will go to that I.C.C. form you will find that the equation is the United States Railroad Administration ten, eight and five: Ten referring to first main track, eight to other main tracks and five to sidetracks. To show that that formula will not work out in this case, let us assume a single track railroad, 100 miles long, and a double track railroad 50 miles long, each handling the same amount of traffic, measured in equated gross ton miles. You can see right off that the traffic density is the same on any individual mile of track, but this formula by reason of giving a weight of only eight-tenths to the second main track distorts the answer.

Proceeding to the next page, the question comes up as to how we shall use this traffic unit after it is once obtained. So far as I can make out from this report there is no method of use outlined. Certainly, the Committee does not wish us to understand that if the traffic density or traffic intensity on one road is twice what it is on another, or in one year

is twice what it is in another, or one on division twice what it is on another, the tie life may be expected to be one-half what it is on the other. Most certainly the Committee does not want us to do that, but they have not shown us how we shall use the traffic unit after it has been obtained.

Mr. A. F. Maischaider:—We did not attempt to try to show how the traffic unit should be obtained. We all know it is not in direct proportion to the density of traffic. It is merely that it is a unit that affects the life of the tie. It may be it only affects it one-twentieth, or maybe it affects it more. That is all we have tried to do. We expect to develop some other formula later to show how this unit should apply or why it should apply.

As to the use of the equated track miles maintained, what we have tried to do is select the unit that we could get from available statistics, but that were no statistics other than those that I know of that we could get.

Mr. H. C. Crowell:—Is it meant there are no statistics of the miles of main track or miles of total track maintained? The only thing I am objecting to is the fact you are applying the factor of eight-tenths to the second, third and fourth main tracks. Most certainly we have statistics of the miles of main track in use.

Mr. A. F. Maischaider:—Yes, but we have not figures as to the number of ties maintained per mile of track maintained. The figures that we have are the number of ties maintained per equated track mile. We do not have it direct. I do not know where you could get it. I talked this over with the Assistant Director of the Interstate Commerce Commission, Mr. Seeley Dunn, and he could not cite me any other statistics that are available. Of course we did the best we could.

Mr. H. C. Crowell:—If we have something here that is not right, let us not put anything into the Manual until we get something that is right. If what is right is not available, let's say so.

Mr. A. F. Maischaider:—We do not want to put it in the Manual. We want to put it out as information.

Mr. Crowell:—For the Manual next year. That is what the report says.

Vice-President Yager:—This is a very important subject. We have tried to make our tie statistics useful in comparisons. Tie renewals are one of the most important elements of maintenance, and the question is often asked how we are to account for differences in use to which ties are subjected. It was the purpose of the Outline of Work Committee in assigning this subject to have the Committee develop a factor expressing the difference in use, in order to make tie renewal statistics more comparable. From the presentation of the information and the discussion which has developed it is apparent that the subject is beginning to bear fruit.

The Committee is very grateful for the suggestions which have been offered, particularly by Mr. Crowell, and they will endeavor to reconcile these differences which Mr. Crowell has pointed out.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I should like to suggest to the Committee that after they have formulated

their factor, they take up the study of its application, including such items as the section of rail, the extent of application and size of tie plates, the extent of application and character of ballast, and the element of labor is one which should not be lost sight of.

Vice-President Yager:—As I said before, the Committee is very thankful for these suggestions that have been offered and any others that you can offer. It is a very complex subject, as you can appreciate. If there are no further suggestions the report will be received as information and the subject will be reassigned.

You may proceed, Mr. Chairman.

Mr. R. S. Belcher:—The next subject is Data on Average Ties Renewed per Mile of Maintained Track. This is Appendix F on page 254. Mr. J. H. Roach, the Chairman of the Sub-Committee, is not present. This subject has been studied for the last two years by the Tie Committee, and, as was stated last year, it has been a requirement of the Interstate Commerce Commission for a number of years that certain statistics relating to cross-tie renewals be included in the reports made annually by each railroad.

Prior to 1927 it was not possible, from the statistics as reported, to determine accurately the number of renewals made per maintained mile. As was reported last year the Committee made suggestions to the Interstate Commerce Commission that by modifying the form of railroad reports slightly, information as to renewals per maintained mile could be had. The suggestion was favorably received by representatives of the Commission, and statistics in revised form will be available, we anticipate, from 1927 on. It has been thought best, in view of this, to defer the first report on this subject until next year.

Vice-President Yager:—It will be received as information.

At this point we desire to call your attention to an innovation in the procedure of the Association's affairs, and direct your attention to Bulletin 305, in which appears the outline of work and personnel of committees. The purpose of this change was to permit an earlier organization of committees and resumption of the year's work immediately after the close of the Convention. These outlines as presented here are subject to minor modifications as dictated by developments during the Convention. I believe it would be well for all of those who have served and expect to serve on committees to familiarize themselves with these outlines.

If there is nothing further, the Tie Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON BALLAST

(For Report, see pp. 355-363)

(Vice-President Louis Yager in the Chair.)

Mr. Paul Hamilton (Cleveland, Cincinnati, Chicago & St. Louis):—Mr. Chairman, the report of the Ballast Committee is found in Bulletin 301, beginning on page 355. The Committee this year reports on five subjects, the first of which is Revision of the Manual. The report on this subject is to be presented by the Chairman of the Sub-Committee, Mr. C. J. Coon.

Mr. C. J. Coon (New York Central):—The subject assigned this Sub-Committee was Revision of the Manual. The Committee collaborated with Committee XII—Rules and Organization, with the object of determining what subject-matter now appearing in the Manual under Ballast might properly be incorporated in the work of the Rules and Organization Committee. It was found that the matter on pages 83 to 86, inclusive, of the Manual under the caption "Instructions to Govern Ballasting on an Operated Line" should be properly included in the rules to govern conduct of work.

It was agreed that the Committee on Rules and Organization will submit to the Association for approval rules to govern the conduct of ballasting operations.

The Committee recommends that the Instructions to Govern Ballasting on an Operated Line, appearing on pages 83 to 86, inclusive, be eliminated from the Manual upon the adoption by the Association of rules covering this subject presented by Committee XII—Rules and Organization.

The Sub-Committee collaborated with Committee XII, and the information referred to is found on pages 516 to 519 in Bulletin 302, which is the report covered by Committee XII. Nearly all the information included in this report is found in the Manual and appears on pages 83 to 86. There were no other changes in the Manual recommended at this time.

Vice-President Yager:—If there is no objection, the subject-matter presented will be acted upon when presented by the Committee on Rules and Organization.

You may proceed, Mr. Chairman.

Mr. Paul Hamilton:—The next subject assigned was: "Make Critical Review of the Material now Appearing in the Literature of the Association Relating to Ballast." The Chairman of the Sub-Committee, Prof. C. B. Stanton, will present the report.

Prof. C. B. Stanton (Carnegie Institute of Technology):—Referring to the data on page 357, Bulletin 301, marked Appendix B, your Sub-Committee received replies to about 26 per cent of the questionnaires sent out, with the results tabulated in the Appendix. Although very few railroads indicated that they had adopted in toto the recommendations, sections or specifications, there was the thought expressed by nearly all that the Association's sections and specifications furnish data on which to base the sections or specifications used by the individual road.

The Committee therefore recommends that no change in the sections or specifications be made at this time.

Mr. Chairman, I move that the report be received as information.

Vice-President Yager:—If there are no objections, it will be so received.

Mr. Paul Hamilton:—The next subject reported on is as follows: "Investigate the Comparative Values of Various Ballast Materials, with Special Reference to Drainage and Effect on Costs for Track Maintenance." The Chairman of the Sub-Committee, Mr. Daniel Hubbard, will present the report.

Mr. Daniel Hubbard (Chesapeake & Ohio):—In connection with this subject, the Sub-Committee sent out a questionnaire to forty-three railroads. Answers were received from twenty-one, and those received were of such a variable nature, it was difficult to tabulate anything in the form of a report that would be concise. The conditions and the materials used were dependent on the traffic conditions, conditions of subgrade, and it was extremely hard to arrive at any definite conclusion. Where traffic is heavy and subgrade conditions are such that frequent surfacing is necessary, the same results cannot be obtained as where the subgrade conditions are normal. On drainage conditions there seemed to be quite a diversity of opinion. Some contended for rock, some for gravel and some for slag, and as it was all dependent on the condition of the road that was operating, it was very hard to arrive at anything definite.

The Committee has not endeavored to take into consideration the actual costs represented in dollars and cents, as it was found that where this would be of value, say to one line, conditions vary so greatly, it would not be of value to another line. For this reason, the Committee did not go into any definite cost data. It is recommended that a study of the subject be continued for another year.

Vice-President Yager:—Unless there are some suggestions to offer to the Sub-Committee, it will be received as information.

You may proceed, Mr. Chairman.

Mr. Paul Hamilton:—The next subject is found in Appendix D, "Make Critical Study of the Cause and Effect of Pumping Joints in Railway Track and the Excess Cost of the Maintenance Resulting Therefrom." The report will be presented by the Chairman of the Sub-Committee, Mr. L. L. Adams.

Mr. L. L. Adams (Louisville & Nashville):—As pumping joints are so largely controlled by local conditions, your Committee attempted only to make a report that would cover the entire subject in a general way. The five causes given on page 359 will enter in some way into most of the cases of pumping joints, and the remedies we give on page 360 and 361 we think will also apply in a moderate way in most cases, but each case will have to be governed on its own merits. It is our opinion that the best remedy of all is good tamping, and to keep the bolts tight. That will help to keep the joints from starting to pump, which is much easier than stopping them after they have started.

I move that the report as given be received as information.

Vice-President Yager:—Unless there is objection, the report will be so received.

Mr. Paul Hamilton:—The last subject reported on is: "Investigate and Report Upon the Shrinkage of Ballast Materials." The Chairman of the Sub-Committee, Mr. E. I. Rogers, will present the report.

Mr. E. I. Rogers (Peoria & Pekin Union):—This information appears in Appendix E, pages 362 and 363, of Bulletin 301. A synopsis of these two pages is about as follows: Investigation so far conducted leads this Committee to believe that great care should be exercised in the reports of the ballast material, that is, with respect to the report of measurement, if purchase is made by volume, and with reference to the unit for conversion from weight to volume, if purchase is made by weight. It has previously been determined that practically all reports for accounting and engineering purposes are made by the cubic yard, and considerable difference will result unless care is exercised in the determination of the units for conversion.

It is the consensus of opinion of this Committee that the per cent of shrinkage heretofore referred to by the Ballast Committee is the per cent lost in volume from point of origin to and including the placing under track.. Due to conditions this Committee has been unable to secure definite information as to the compacting and solidification of ballast after having been placed in tracks, and these tracks turned over for traffic.

The Committee, through the co-operation of the members of this Association, hopes to be able to secure definite information in the ensuing year for presentation at the next meeting.

We have decided that the matter of shrinkage of ballast under an operated railroad after a period of time of course depends upon several things, and it has been found in practically all of the investigations that we have not sufficient data, starting with the ballast at the pit and ending up in the track, and then studied for a period of years. We found that whatever shrinkage heretofore was considered as taking place from the pit to and tamping in the track was one of volume. After the ballast is hauled and again unloaded its volume is virtually re-established, and then there is some compacting which takes place in the tamping under the ties, but the percentages heretofore shown in the Manual are not changed, and we want to continue to study this subject, and ask the help of the members of the Association in giving us the information and data that we ask for in our report, Appendix E.

Vice-President Yager:—Are there any suggestions to the Committee in connection with this important and quite controversial subject? The Sub-Committee has given us the assurance that they are taking the proper precautions to get the right sort of measurements and have them supervised so they will be able at sometime to definitely settle this subject for us. If there is nothing further, the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON IRON AND STEEL STRUCTURES

(For Report, see pp. 365-374)

(Vice-President Louis Yager in the Chair.)

Mr. B. R. Leffler (New York Central):—The report of the Committee is found in Bulletin 301, beginning on page 365. I will read the subjects recommended.

(9) Punched and Reamed Work (Appendix A).

Action recommended: That the report on punched and reamed work be received as information.

Vice-President Yager:—If there is no objection, it will be so received.

Mr. B. R. Leffler:—On Subject No. 1, Revision of Manual, investigations and tests on a number of subjects are under way, including bearing values of large rollers, testing of I-beams in groups, investigation of copper-bearing steel for structural purposes, and tests on columns. The work on these subjects has not progressed far enough to enable the Committee to make any recommendations for revision.

On Subject No. 2, Specifications for Steel Highway Bridges, the Sub-Committee has been in conference with the American Association of State Highway Officials in drafting a Specification for Highway Bridges. The subject-matter is complete and is in the hands of the editing committee. However, the completed specifications cannot be ready for presentation to the convention this year.

I will ask the convention to endorse the following request: Committee XV had a meeting in February, only a few weeks ago, and the Chairman of the Sub-Committee presented his report; a copy of the manuscript of this report is in the hands of Secretary Fritch. The Committee would like to have the endorsement of the convention for the privilege of publishing this report in the April Bulletin. I discussed this matter with Chairman Brumley at the noon hour. The Committee regards the report as so valuable that it should be put in print as soon as possible for the purpose of getting it before the Association and before the public as a means of trying out the specifications for the coming year, before recommending adoption in the Manual. It is in the nature of a progress report.

Mr. Kelley, who is Chairman of the Highway Association, has endorsed the report. Mr. Hunley is not present today, but Mr. Selby, who is a member of the Sub-Committee, is well acquainted with the details, and I will ask him to explain the work of the Sub-Committee, so that the convention can act on the matter with intelligence.

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—The specifications which are being presented at this time in the nature of a supplementary report of Committee XV are the result of about three years' work on the part of a Conference Committee, composed of three representatives from the Committee on Iron and Steel Structures and three representatives of a similar Committee of the American Association of State Highway Officials. In addition to these six members of the Conference Committee, there have sat in with the Committee in an advisory

capacity, Mr. Otis E. Hovey, representing in an unofficial way the American Society of Civil Engineers. Mr. Hovey is also a member of this Association and this Committee, and Mr. Welty a member of this Committee. We also have had the benefit of the advice of Mr. Lee Miller, Chief Engineer of the American Institute of Steel Construction.

The basis of the work of the Conference Committee was the specifications submitted to the Association by this Committee about four years ago and printed in the Proceedings as information, and the specifications of the American Association of State Highway Officials which were promulgated at about the same time as a bulletin of the Bureau of Public Roads.

I may say that a most commendable spirit of co-operation has existed within the committee, representatives of either side not having approached the matter in any other than a purely technical, professional way, and with no desire or effort to make a partisan or one-sided matter of any of the subjects. There has been no account kept of the number of clauses adopted from one specification or the other. We agreed in the beginning to work with a view of getting a good specification, the best specification we could produce as individuals and engineers, regardless of our society affiliations. That spirit is the more commendable and outstanding because of the different spirit manifested by a representative of another association in another similar matter with which this Committee has been concerned recently.

The specifications which were printed in the Proceedings a few years ago, the specifications of this Committee for Highway Bridges, were produced with the idea of getting a discussion on them, and a great deal of discussion was brought out. The members of the Conference Committee found on going into the subject that those specifications were not perfect. If I do say it myself, the highway fellows knew more about the subject than we did in some respects; on the other hand, there were some aspects of the highway bridge problem that were peculiar to the railway field, and the representatives of the highway men (I do not use that as one word but I mean highway *men*) admitted that they had something to learn from the railway men. We pooled our knowledge and pooled our problems and we are very much gratified at the result.

The specifications proposed are in the process of being printed, they are available now in mimeograph form, but the time was too short to get them printed to submit to the members at this convention.

If the action of this convention is favorable to receiving them as information, they will be printed in the next Bulletin and will be available in pamphlet form. There has been a great demand for them from railway engineers who have highway problems to deal with, and most all of us have. We are in constant negotiations with highway officials for crossings of railways and highways, and there is need for specifications which are acceptable to both parties.

The edition of the specifications printed a few years ago has been exhausted and it has been realized that those specifications were not complete nor in the best form. The desire now is to supply the demand for

an up-to-date highway bridge specification which will be available to the railway engineers.

Vice-President Yager:—I am sure that the convention is gratified to learn of the favorable outcome of the co-operative work which this Committee has done with other committees and that they have been able to develop this specification. I am also sure there will be no objection to complying with the request of the Committee that these specifications be formally placed before you in the next Bulletin to be issued.

Mr. B. R. Leffler:—On Subject No. 5, Column Tests, the Committee is collaborating with the Column Committee of the American Society of Civil Engineers, of which Dean Turneaure is Chairman. Under the direction of Dean Turneaure, experiments are being made on columns loaded eccentrically. The purpose of these experiments is to determine the longitudinal shearing effect on columns and the necessary strength of lacing. Final report on this subject cannot be made at this time.

I will say that there are several members of this Committee who are also members of Dean Turneaure's Committee.

On Subject No. 6, Investigation of Copper-Bearing Steel for Structural Purposes, the use of copper-bearing steel for various industrial and structural purposes is increasing; it is now being used in the manufacture of steel cars, tie plates, track spikes, smoke-stacks, stationary boilers, metal culvert pipes, metal flashings, ventilators, wire fencing, light structural steel for warehouses, steel sash, power line supports, flood light towers, and overhead electrification structures for railway tracks.

Copper-bearing steel in such service has, in many instances, been found to last twice as long as ordinary steel. It has been little used in railway bridge construction, but records show its use in several important highway bridges. Its application for structural purposes is widening, and its use is now extending to roof trusses in railway shop buildings that are exposed to marked corrosive influences.

Copper-bearing steel can be readily secured at slight increase in cost.

We submit this on the subject of copper-bearing steel as information without any recommendations as to use just yet.

On Subject No. 10, Investigation of Bearing Pressures on Large Rollers, the investigation has brought out much new and valuable information on the bearing values of rollers. Tests to determine the bearing value of large rollers have continued through the year at the University of Illinois. Rolling tests have been made on plates of medium grade steel castings varying in thickness from 0.5 inches to 4 inches when rolled by cylinders having diameters of 188 inches, 356 inches, and 476 inches.

Funds have been obtained from the Scherzer Rolling Lift Bridge Company which, added to the remainder of the appropriation from the A.R.E.A., enabled the University to employ a half-time graduate research assistant to continue the tests.

A Conference Committee composed of members of Committee XV, and representatives of the American Society of Civil Engineers, are de-

veloping Specifications for Steel Railway Bridges. This committee is approaching the completion of its preliminary work, and it is quite possible a new specification will be presented to the convention in 1929 as information.

No definite progress was made during the year on the other four subjects of the Committee's Outline of Work, namely:

3. Electric welding of connections in steel structures.

4. Investigation and tests of I-beams connected in groups by diaphragms and bracing.

7. Influence of dead load upon the impact from moving loads on bridges.

11. Specifications for steel tanks and their supports for the storage of water and oil—collaborating with Committee XIII.

Vice-President Yager:—The Secretary received this morning a letter from Mr. Hunley, Engineer of Bridges and Structures of the Big Four, who was also a member of this Committee, giving some interesting information in connection with tests which were made on the Swift Island Bridge of the Yadkin River in North Carolina. This will be communicated to you in the next Bulletin that is published, so it will be a part of the report of this Committee.

If there is nothing further for the Committee to report on, they are excused with the thanks of the Association. (Applause.)

DISCUSSION ON WOODEN BRIDGES AND TRESTLES

(For Report, see pp. 503-512)

Mr. W. E. Hawley (Duluth, Missabe & Northern):—The report of this Committee is rather brief this year. The Manual having been before us for publication for some time, the Committee has made no further changes in the Manual for this year. Unless there is somebody on the floor who has something to bring up in connection with the revision of the Manual, the Committee is ready to pass that subject.

The President:—Are there any suggestions from members of the Association regarding the Manual of this Committee? If there are none, you may proceed, Mr. Chairman.

Mr. W. E. Hawley:—The second subject, Simplification of Grading Rules and Classification of Timber for Railway Uses, collaborating with Committee XII—Rules and Organization, and other organizations dealing with this subject, will be presented by Mr. C. J. Hogue, Chairman of the Sub-Committee.

Mr. C. J. Hogue (West Coast Lumber Trade Extension Bureau):—The report of the Sub-Committee on Grading Rules and Classification of Timber for Railway Uses is printed on page 505 of Bulletin 302, and records that these rules were adopted by the Association two years ago, based on American Lumber Standards, that they were slightly revised last year, and that during the year nothing has suggested itself requiring further revision or modification. That is with regard to the rules for softwood lumber. The rules for hardwood lumber have not yet been completed, but progress has been made.

The job, now, is to put these standards into use. The lumber manufacturers' associations have adopted rules based on American Lumber Standards, and all previous rules have been withdrawn. It takes time to establish new rules, but the copyrights for these rules are held by the lumber manufacturers' associations and previous ones will not be reprinted.

I think we can report that satisfactory progress is being made in establishing the new rules. We have not yet had the report for this year on the extent of use of the new rules, but probably seventy-five to eighty per cent of the lumber produced is manufactured and sold on the rules based on American Lumber Standards, and certainly more than that percentage of the lumber manufactured and sold by the more important mills is bought by the railroads and the more important buyers.

The important matter this year is the factor of identification and certification of grades through grade marking or other means. That project or the factor in the situation has been recommended by the lumber manufacturers' associations, and a great deal of progress has been made in putting it into effect. There is some resistance, partly from practical standpoints and partly from the question of advantageousness, but it is the principal factor under discussion this year, and while last year there was

nothing to occasion a general conference on lumber standards, Secretary Hoover, of the Department of Commerce, has called such a conference in Washington the first of May this year and the principal subject will be the one of grade marking or other means of identifying and certifying the grade.

It goes without saying that that should be done for the ultimate consumer; whether it should be done entirely by the manufacturer or partly by the distributing yard between the manufacturer and the consumer depends somewhat on the item and the use, but it will be discussed this year at Washington in May, and it is hoped that very satisfactory progress will be made at that time toward this important point—identification and certification of grade.

The President:—The report of this Sub-Committee is a progress report, but if anyone has anything to suggest, we will be glad to have him do so. If there is nothing to be added to this report, you may proceed, Mr. Chairman.

Mr. W. E. Hawley:—The next subject that is before this Committee is: Prepare a revision of present Specifications for Treated and Untreated Timber Piling, collaborating with Committee XVII—Wood Preservation. Professor Paul was Chairman of the Sub-Committee, but he is absent. In his absence I will attempt to present the report for him. This report was initiated largely through the Wood Preservation Committee, which was considering treatment for piling to preserve and make it last longer. They felt that the fundamental specification for piling should come from this Committee, and this Committee agreed with that viewpoint. This Committee does not concern itself with treated timber or treated piling in so far as the processes are concerned. This Committee is working only on the specification for timber or for piling untreated.

However, this specification was gotten up in collaboration with this Committee, and we received many suggestions from them, and also from the American Wood Preservers' Association. I think it can be said that this specification is a compromise specification, as many of the other pieces of work of the Committees of this Association necessarily must be. I am sure the specification will not meet the approval of every man who has made suggestions to the Committee, but the Committee is offering it, feeling that it is the best that can be done in a compromise specification, and would like to offer it this year for your acceptance.

I would move that this report be accepted for printing in the Manual as a specification of the Association. I believe it is in order, Mr. Chairman, to read this by paragraph titles and to receive any comments on each paragraph as we go through.

The President:—All right, sir.

Mr. W. E. Hawley:—The first sub-title is "Kinds of Wood." Does anybody wish to make any comments? The second subject is General Quality, under the main subject of Physical Requirements. Close grain; resistance to decay. Under Design is dimensions, first-class piles; dimensions, second class piles.

I might offer this information that some feel our dimensions are a little too heavy for highway work and others may feel that they are too light for heavy railroad work, but there must be some value chosen, and the Committee has set forth these tables of dimensions here as probably being mid-ground and reasonable enough.

Tolerance; length; straightness. Manufacture. Under Inspection, place, manner, manufacture. Delivery. Shipment. Unless there is some suggestion from the floor on any subject I have passed I make the usual motion.

The President:—Mr. Hawley's motion is on the adoption of the specifications for publication in the Manual. Is there a second?

It is moved and seconded that the specifications appearing under Appendix C, entitled, "Prepare a Revision of Present Specifications for Treated and Untreated Timber Piling, collaborating with Committee XVII —Wood Preservation," be adopted. Is there any discussion?

Mr. J. L. Pickles (Duluth, Winnipeg & Pacific):—Unfortunately I do not have the Bulletin at hand containing this report and if not out of order, I should like to suggest that the committees be arranged so as to take up the work in the order of the Bulletin numbers.

I should like to have a clause stating that the timber should be loaded in so far as practicable by cars of one dimension, and not mixed up in various sizes on one car.

Mr. W. E. Hawley:—Mr. Chairman, the nearest subject that we have to that is the question of shipment which is in paragraph 27, on page 509, "Piles forwarded in cars or vessels shall be separated therein according to the kinds, sizes and lengths if inspected before loading, or as may be stipulated in the contract or order for them."

There are other phases Mr. Pickles may be interested in, such as staking and chaining. I have no idea what he has alluded to. I will be glad to have him refer to any detail omitted in this specification.

Mr. J. L. Pickles:—As I stated, I did not have the Bulletin. I withdraw my remarks.

The President:—Is there any further discussion?

Mr. M. Hirschthal (Delaware, Lackawanna & Western):—I want to call attention to Section 10, "Piles for use without preservative treatment shall have as little sapwood as possible." Could not that be made a little more definite? "As little as possible" does not mean very much as a clause for rejecting a pile not coming up to the specification.

Mr. W. E. Hawley:—The Committee in their consideration of that paragraph tried to put in some percentage, something like eighty-five per cent or some such value, but it was found that because of the difference in different kinds of wood, difference in thickness of the sapwood and difference in the way of expressing it, the Committee came to the conclusion that the most practical way in the general specification was to put it in this form, which I will admit is somewhat indefinite, but the minute you begin to make it very definite you make it hard to fit in the general specification all the kinds of wood used for piling in this country.

The President:—Is there any further discussion? The question is on the adoption of the specification of timber piles for publication in the Manual. Those in favor of the motion will say "aye"; opposed "no." The motion is carried.

Mr. W. E. Hawley:—The fourth subject before the Committee is "Study and Report Advantages of Establishing Supply Yards for Standard Trestle Timbers at Various Locations Throughout the Country." Mr. Grear is not here. I would like to ask Mr. F. M. Hawthorne if he will present that subject to the convention.

Mr. F. M. Hawthorne (Pennsylvania):—The Committee had this subject thrust upon them. They have struggled with it this year quite a bit. The questionnaire was sent out to all the member railroads of the Association. I believe they were all covered and the replies received indicate rather definitely that most of the railroads are not very much interested in this subject, at least they are unable to agree on a location for the establishment of certain yards. With the above data it would appear it would not be possible at the present time for the Committee to make a favorable recommendation. The Committee recommends that this report be received as information and the Committee give the subject further study during the coming year.

The President:—Are there any questions to be asked regarding the report on the advantages of establishing supply yards for standard trestle timbers?

Mr. Robert H. Ford (Rock Island):—It would appear from the remarks of the last speaker that the Committee have canvassed the railways but did not get a satisfactory response. What little information they did get was evidently to the effect that the reporting roads had given little thought to the benefits or desirability of regional supply yards in different parts of the country. It would appear that this is largely a question of marketing and that there are other related matters connected with its consideration, in which railway maintenance of way and construction are more or less concerned and upon which a good deal of data should be available.

The report appears rather nebulous and it is to be hoped that something of a more constructive nature, through progress or otherwise, will later be made.

Mr. W. E. Hawley:—We appreciate the thought expressed by Mr. Ford. The Committee has thought that there were possibilities for some economies to be introduced into the railroad use of timber by pooling their source of supply. There were two chances either in combining between different railroads to pool their supply under railroad control, or to encourage private business to so locate depots of supply of usual sizes of heavy timber that in the case of emergency these supplies could be called upon to supply the needed material for replacement.

There has been in the lumber industry some effort, already some initiative taken by some of the producers of heavy timber, to supply depots where this material may be secured. I think, however, that there is still a feeling on the part of those in the railroad field who have to do with

meeting emergencies that they want the source of supply of timber closer to home than in a pool of other railroads or in private hands, and they desire to carry stock to the plan of each road trying to anticipate its own future requirements by buying and maintaining stocks of materials on its own property.

The Committee was somewhat uncertain as to whether to try to finish the subject this year or not, but it was felt that the Committee would like to not give it up this year but attempt to further study the subject, and I am hoping that Mr. Ford's desire for more definite conclusions, either positive or negative, may be arrived at to present at the convention a year from now.

The President:—If there are no objections, the Committee will continue the study of this subject this year and report at the next annual convention.

There is a subject in connection with the uses of timber that seems to be very important to the timber industry as well as the manufacturers of timber and the users of timber. If Mr. P. A. Bloomer, General Manager of the Louisiana Long Leaf Lumber Company, is in the audience, we will give him an opportunity to tell us in ten or twelve minutes what this subject means.

Mr. P. A. Bloomer (Louisiana Long Leaf Lumber Company):—With the indulgence of your worthy President, I am appearing on behalf of the Southern Pine Association, not to give any propaganda at all, but to discuss a very important subject to you and to us.

I might say that the shipments of the members of our association will aggregate about 4,000,000,000,000 feet per annum. The activities have, in a large measure, been devoted to better manufacture and preparation of the lumber produced by its members. It was in the forefront in helping complete the standardization program. Its policy of grade-marking and trade-marking is one of the most forward steps ever taken by the industry. Its grading rules and corps of expert inspectors have long been a guarantee to purchasers that only honestly graded lumber need be paid for. These grading rules undertake to describe and limit the defects in the several grades, so that any intelligent man can correctly inform himself as to their application. From some quarters comes a demand that an additional defect be covered by these rules, that of shrinking and swelling.

While our association has studied the matter for some time, we have come to no conclusion as to just how this should be handled in our rules, but it has given us manufacturers a better knowledge of our product and has further confirmed our belief that this defect seldom occurs to any serious extent in shipments from our members.

As you all know, this defect working is caused by either excessive or insufficient moisture in the lumber. The green lumber from the saw mill contains water or moisture in two forms, first, in the cell cavities or pores, called free water, and, second, in the cell walls intimately absorbed in the substance of which wood is composed called imbibed water, or hydroscopic water. The removal of any of the free water apparently has no effect on the physical properties or the shrinkage of the wood. The

point at which all the free water is removed is called the fiber saturation point. It is when the imbibed water begins to leave that the lumber begins to shrink, and it will continue to shrink until all this moisture is driven out.

In order to hasten the departure of this imbibed water and incidentally surround the operations with better drying facilities and humidity conditions that may obtain in the open air, steam dry kilns are employed. In their operation many problems are presented. As the outer surfaces of the board reach and pass the fiber saturation point they begin to shrink. This shrinkage is resisted by the green wood inside, since it has not reached the fiber saturation point and therefore is not ready to shrink of its own accord. Stresses are set up which will cause injury to the lumber, unless proper precautions are taken.

Lumber of the same species, for that matter from the same tree, will differ as to the amount of water it contains. Frequently lumber cut from butt logs requires more time for drying than that from the top logs, but the lumber must be all put in the kiln together and humidity and temperature conditions so regulated that no damage be done to the lumber.

It is imperative that we know when the lumber is to be removed from the kiln, and this is not left with a guess. Short pieces, or samples, about two feet long are cut from the lumber as it is being loaded on the kiln cars, and after coating the ends and accurately recording their weight are placed back on the car with the lumber. In cutting these samples we endeavor to have them representative of the average condition of the load. By calculating the weight of these samples at any given moisture content, we are enabled to determine how the drying process is proceeding.

When the lumber emerges from the kiln some of it will probably approach bone dry while the balance will vary in its content of moisture, but not much above the mark set by the operator in the beginning.

Wood is a hydroscopic material. It has a definite affinity for moisture and it is a natural condition that it contain a certain amount. There is a definite balance between moisture in wood and the humidity in the air. Even though it were possible to drive out every bit of the moisture in the drying process, when later exposed to the air, it will effect a balance with the moisture in the atmosphere.

The relative humidity of the greater part of our country will run around 75 per cent. Of course, such places as Phoenix, Arizona, and El Paso, Texas, have a much lower humidity.

The Forest Products Laboratory, by actual data, have charted the relation between moisture in the wood and the relative humidity of the surrounding air at certain temperatures. From this chart it would appear that wood, no matter how dry it had once been, when later exposed to the air for a sufficient length of time will attain a moisture content of about 12 per cent.

Strictly speaking, the point at issue is not the amount of moisture in the wood, but the working proclivities after use. United States Forest Service tests show that the shrinkage from green to oven-dried conditions of longleaf yellow pine measured tangentially is 7.6 per cent, and the fiber saturation of that wood is about 25 per cent.

We shall suppose that a piece of car siding, four inches in width, contains 12 per cent moisture when applied to the car and later, owing to humidity conditions, this moisture is decreased to 9 per cent. The shrinkage that would take place would be insignificant. I mention this car siding because, of all other material used by railroads, it should bear a representative amount of moisture. It moves from place to place under varying humidity conditions.

I had an opportunity just the other day, where they were tearing down a couple of cars in Shreveport, of securing a bundle of the siding that was taken off, and that had been put on there about four years ago. They very graciously gave me a bundle. After taking its content, it varied, but none of it was below 10½ per cent, and much of it was over 12 per cent. These pieces of car siding were very dense, close-ringed, long-leaf stock and had every evidence of being thoroughly kiln dried, so that rather confirmed the statement I have just made.

The task of ascertaining moisture content requires great care, else incorrect results are probable. There is only one accepted way of doing it. I assume you are all familiar with that, but it is open to a great many errors. Wood dries and takes on moisture most quickly at the ends. It is this moisture section that we cut to place in the oven. If it is not cut from a distance from the end it will not be representative. There frequently will be some fuzz or whiskers left on this small section. If they are included in the green weight and disappear before taking the dry weight, the result will be wrong.

Then there is the question, what is bone-dry or oven-dry, the point to which we must get this in order to figure the moisture content. It is to be that when it ceases to lose weight in the oven. Many maintain that absolutely dry wood cannot be secured for the purpose of this calculation because chemical destruction sets in before all the water is evaporated. Certainly in the case of yellow pine there is an amount of oil, turpentine, etc., which will vaporize with the moisture which tends to incorrectly indicate a higher moisture content.

I am convinced that a large portion of this agitation for a definite limit of moisture in lumber is not caused by anyone shipping lumber, even from 12 to 14 per cent, but it is the result of our markets being flooded with unidentified lumber of all species, and to the seasoning of which little thought or attention was given in the drying process.

Knowing that green lumber will eventually shrink, some engineers and architects have placed a moisture limit in their specifications. In order to be on the safe side, many of them have put a figure so low that to my mind it is unattainable.

It is not good practice to dress or match lumber hot from the kiln. It is, at that time, not in a normal condition due to the stresses that have been set up with the departure of the moisture. Many follow the practice of bulking it down in the shed for ten or fifteen days before sending it to the planing mill. From the time that lumber emerges from the kiln

at a low moisture content it will continue to condense moisture from the atmosphere until a balance is effected.

The condition really desired is that lumber does contain that amount of moisture which will insure its retaining a permanent size, as far as possible, under all atmospheric conditions.

In the enactment of regulatory and restrictive laws, our legislators endeavored to place a curb on wrong practices. In framing these laws they should use great care that in their anxiety to reach certain offenders they do not hamper or wrongly interfere with legitimate business. Some of our railroads will bear with us the burden placed on them in the enforcement of certain laws, both state and national.

There are manufacturers who will ship green, or far from dry, lumber when to their knowledge the purchaser expects and requires that it be dry. There is no law to regulate or restrain them. In your specifications you may seek to prevent their foisting such stock upon you. In covering the matter of dryness you should in all fairness give consideration to the physical properties of wood and place a limit that can be met by those mills in operating practice and followed in the best manner that the industry knows.

There is one source from which you can obtain what you want and what you order. It is from that large number of manufacturers of yellow pine whose faith and pride in their product is such that they plainly stamp the grade and the mill number on the end of every piece of lumber they ship.

I am sure that wood as a structural material engages your interest now and will continue to do so. When writing your specifications no doubt you are guided and influenced largely by your knowledge of, and your experience with, wood. This depends, of course, on the adaptability and availability and, perhaps most important of all, its economic aspects.

There have been a lot of exaggerated statements made about all this, ranging from the fellow who says, "Insist that the lumber be bone dry, that it does not contain any moisture," and I have heard statements from a man who is very intelligent on other matters. It will range from him to the slovenly manufacturer who cares very little about it, just so he can dispose of his lumber.

As individuals we will get nowhere. We will make very little progress, but if you, who are a good Association, would see fit to appoint a committee to work on this subject and let us, from our association, have a committee to co-operate with you, I am quite sure the results will be mutually beneficial.

I thank you. (Applause.)

The President:—Mr. Hawley, have you anything further to report to the Association?

Mr. W. E. Hawley:—I have nothing, Mr. Chairman.

The President:—If you have nothing further, the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON SHOPS AND LOCOMOTIVE TERMINALS

(For Report, see pp. 375-395)

Mr. F. E. Morrow (Chicago & Western Indiana) :—The report of this Committee this year is upon two subjects, one being on Locomotive Coaling Stations and the other on Methods for the Safe and Convenient Storage of Crude and Fuel Oil and Oil Reclaiming Sumps.

The report on Locomotive Coaling Stations will be presented by the Chairman of the Sub-Committee, Mr. L. P. Kimball.

Mr. L. P. Kimball (Baltimore & Ohio) :—This report will be found in Appendix A on page 376 of Bulletin 301.

In a majority of cases railroad buildings are completely designed by the railroad's engineering department before the work is undertaken or proposals asked. In the case of coaling stations, however, it is the usual practice to have the design made for approval by the manufacturer or contractor, and to secure proposals and place the contract before this is done. As a basis for securing such proposals and later for checking design, it is desirable to have a well-considered set of specifications that will assure to the purchaser a complete and satisfactory structure, and still permit as wide a field of competition as is desirable.

The typical specifications submitted in Appendix A, beginning on page 380, have been prepared with the above object in view and are submitted as a guide to the items necessary for consideration.

Allied with these typical specifications are the conclusions also in Appendix A on page 376. These conclusions outline the items that must be considered for each individual coaling station project, and which should be used as the basis for the preparation of a special specification to accompany the invitation for proposals.

In addition to the above-mentioned typical specifications and conclusions, it will be necessary, as also indicated therein, to make the necessary provision to cover structural design, character of materials and workmanship, which are not peculiar to coaling stations and upon which adequate recommendations are already available in the records of the Association, having been submitted by other committees.

It is the recommendation of the Committee that the conclusions and typical specifications be approved for publication in the Manual, and I desire to offer a motion to that effect.

The President :—It has been moved and seconded that the conclusions and specifications reported to you be approved for publication in the Manual. The question is now open for discussion.

Will you please read the headings and give the members an opportunity to call attention to the defects, if there are any?

Mr. L. P. Kimball :—I will begin for that purpose the typical specifications, which are on page 380, the first paragraph being General. The conclusion is beginning on page 376, first, Location.

The President:—Are there any questions to be asked this Committee on this question? It would seem that this Committee is to be congratulated on presenting conclusions and specifications that are absolutely holeproof. If there is no discussion, the question is on the adoption of the specifications and conclusions for publication in the Manual. Those in favor will say "aye"; opposed "no."

(The motion was carried.)

The President:—You may proceed, Mr. Chairman.

Mr. F. E. Morrow:—The report on methods for the safe and convenient storage of crude and fuel oil and oil reclaiming sumps will be presented by the Chairman of the Sub-Committee, Mr. J. M. Metcalf.

Mr. J. M. Metcalf (Missouri-Kansas-Texas):—The Committee has given some further study to the question of storage of crude and fuel oils and submits as information the report printed as Appendix B, on pages 391 to 395 of Bulletin 301. This includes a discussion of the methods in use for protection against lightning and other fire risk in the storage and handling of oil, and information, illustrated by typical plans, of methods in use for trapping and reclaiming waste oil draining away from oil stations.

Since the Committee's report was submitted, and, in fact, within the last day or two, we have received some comment from the Railway Fire Protection Association, suggesting some changes and additions to the matter on fuel oil storage in the Manual, to bring out more fully certain features affecting oil stations from the standpoint of fire prevention. The Committee has not yet had opportunity to consider these suggestions, but would be glad to do so, in conference with the committee of the Fire Protection Association.

The President:—You have heard the methods for the safe and convenient storage of crude and fuel oils offered as information only, and that the subject be continued for the ensuing year. Are there any questions to be asked regarding this?

I think this Committee is to be congratulated on the fact that not a member of the Association asked you a question or offered any discussion at all. It speaks mighty well for the Chairman and the members of the Committee in the work they have just presented to you.

If there is nothing further, Mr. Chairman, the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON RULES AND ORGANIZATION

(For Report, see pp. 513-524)

Mr. W. C. Barrett (Lehigh Valley) :—By reference to the Bulletin 302, page 513, you will find the Committee was assigned three subjects. Before presenting the report, I want to make just a little statement and at the same time acknowledge the appreciation of this Committee for the very splendid cooperation we have had with the other committees during the past year in the preparation of our report. There is not so very much in the report. It seems short, but a great deal of work was done and required a great deal of collaboration with other committees, although in a great many cases no material was presented for report. I thought this explanation was due the Committee and to the other committees because they gave us splendid support, although the actual report of the Committee is brief.

The first subject is Revision of the Manual. You will find the Committee's report in Appendix A beginning on page 515, and Mr. B. R. Kulp, the Vice-Chairman of this Sub-Committee, will present this report.

Mr. B. R. Kulp (Chicago & North Western) :—By turning to page 515, Appendix A, the Revision and Development of Present Rules for Guidance of Employees of Maintenance of Way and Structures Department, perhaps a word of explanation is necessary. The proposed form of rules is on the right side of the page, and where there is already any rule in the Manual, it is copied on the left side of the page. Where no rules are in the Manual, submitted by Committee XII, the word "none" is opposite the proposed rule. These rules were worked up in collaboration with other committees.

The first rules that come under the subject "Ties," Rules 695, 709, 711 and 712, were taken up, discussed and approved by the Tie Committee. At this point I might offer one suggestion in which Committee XII wants to change the wording of Rule 711 to "Ties are" in place of "Ties is," where it states: "When dating nails are applied after the tie is in the track they must be driven the same day the tie is inserted."

Rules 764, 765 and 832 pertain to Track and were worked up in collaboration with the Track Committee.

The next rules pertain to Ballast, and appear on pages 516, 517, 518, 519, 520 and 521, and are Rules 780 to 810 inclusive. These were gone into quite thoroughly with the Ballast Committee, and met with their approval.

Rule 883 is the only rule that pertains to the Roadway Committee, which likewise met with their approval.

By turning then to page No. 521, we have Rules 1759, 1760 and 1761 that were taken up with the Water Service Committee and have their approval.

There are two rules that I would like to back up on and offer a correction: Rule 809 on page 520; the third and fourth lines say: "Tamping machine and stone fork"; change the wording by adding "and/or" making it "Tamping Machine and/or stone fork."

Rule 709 page 515 should read, "Any tie which starts to split" in place of "Any kind of tie, etc."

At this time I would like to make a motion that these rules be adopted and included in the Manual.

The President:—It has been moved and seconded that the rules for the Revision and Development of Rules for Guidance of Employees of Maintenance of Way and Structures Department be adopted for publication in the Manual. The question is open for discussion.

It would seem there are several other committees whose work is involved in rules presented by Committee XII, and this is your opportunity, if you need do so, to present any modifications or suggestions as to these rules that have just been offered.

The Chairman advised me they have all had their say and have approved them. Are you ready for the question?

(The motion was carried.)

The President:—You may proceed, Mr. Barrett.

Mr. W. C. Barrett:—Subject No. 2, Continue the study and report on rules for the guidance of employees of the Maintenance of Way Department, including therein:

(a) Duties of motor car operators and maintainers.

(b) Rules for dressing ballast.

(c) Rules for maintenance of bridges and other terminal structures, collaborating with the proper standing committees. The report on this subject will be found in Appendices B and C.

The action recommended is, on (a), Duties of motor car operators and maintainers. The Committee reports progress on this assignment, but has no definite recommendation to make this year. On (b), Rules for dressing ballast, these rules are incorporated in the rules in Appendix A. They have already been approved. On (c), Rules for maintenance of bridges and other terminal structures, collaborating with the proper standing committees; rules were assembled in collaboration with Committee VII—Wooden Bridges and Trestles, and Committee XVII—Wood Preservation, covering that part of this assignment which calls for rules for maintenance of bridges. Rules prepared are found in Appendix B and are submitted as information only. I will ask Mr. H. J. Pfeifer, who was a member of the Sub-Committee, in the absence of Mr. Priest, the Chairman of that Sub-Committee, to present briefly this report.

Mr. H. J. Pfeifer (Terminal Railroad Association of St. Louis):—Appendix A, as stated by our Chairman, covers one phase of the assignment of this Committee, namely, the rules for the maintenance of bridges and other terminal structures. It covers rules for handling, framing and storing treated piles and timbers. It was worked up in collaboration with the interested committees—Wooden Bridges and Trestles and Wood Preservation. It is submitted as information only.

The President:—If there are no objections, this report will be accepted as information. You may proceed, Mr. Barrett.

Mr. W. C. Barrett:—In Appendix C on page 523 will be found Rules for Maintenance of Other Terminal Structures. This material is submitted as information only, but I am going to ask Mr. A. B. Griggs, who was Chairman of the Sub-Committee, to briefly present that report.

Mr. A. B. Griggs (Atchison, Topeka & Santa Fe):—The report of this Sub-Committee is on page 523. We submit here some proposed rules covering machine and other shop buildings, oil houses, coaling stations, ash pits, turntables and track scales. These proposed rules have not yet been submitted to the other standing committees and for that reason are given here as information. They will be submitted this year to the other committees for their approval or criticism, as the case may be, and we will have them for you next year. That is all, Mr. Chairman.

The President:—If there is no objection, the rules for maintenance of other terminal structures will be received as information.

Mr. W. C. Barrett:—This concludes the report, Mr. President.

The President:—The Chairman advises me this concludes the report of Committee XII. The Committee is excused with thanks of the Association. (Applause.)

DISCUSSION ON ELECTRICITY

(For Report, see pp. 93-143)

The President:—The first report of this morning is that of the Committee on Electricity. Following the custom established a year ago, the meeting will resolve itself into the annual meeting of the Electrical Section. Mr. Sidney Withington, Vice-Chairman of the Electrical Section, will conduct the meeting and receive the report of the Electricity Committee.

(Mr. Sidney Withington took the Chair.)

The Chairman:—Mr. President and Gentlemen: The Electrical Section has unfortunately been obliged to struggle along as best it might without the services and inspiration of its Chairman, Mr. E. B. Katte, during the past year. Mr. Katte has been suffering from quite an extended illness and needless to say he has been very much missed by all the members of the Electrical Section because it has been largely through his effort and inspiration that the Electrical Section exists as it is to-day. We had all cherished a sneaking hope that Mr. Katte would be with us this morning, but his improvement, although encouraging, has not been so rapid as was to be expected, and he is not yet able to be about.

The report of the Electrical Section of the American Railway Engineering Association has been published in Bulletin 301 for November, 1927, and I presume you have all read the report and have noted any comments which you may desire to make.

It is the intention merely to present in outline the work which has been done, and I am going to call as much as possible upon the various representatives of Sub-Committees to outline what they have accomplished.

The first Committee which will report is that on electrical interference caused by propulsion circuits, including recommendations for eliminating interferences with signal, telephone and telegraph lines caused by propulsion circuits and adjacent transmission lines. This Committee has as its Chairman Mr. J. V. B. Duer, but Mr. Duer is not able to be with us to-day on account of illness.

It is to be reported that the work is being carried on mainly through representation of the American Railway Association with other organizations which are interested and through an organization known as the American Committee on Inductive Co-ordination. The representatives of the American Railway Association are Messrs. Katte, Duer, Behner, Jackson, Follett, and Mr. Dryden as an alternate. Mr. Follett is a representative of the Signal Section. There have been no meetings of the American Committee on Inductive Co-ordination since the last meeting of this Section.

It is recommended that the Committee continue to follow the activities of the American Committee on Inductive Co-ordination and report developments from time to time.

Are there any comments on the work of this Committee? If not, I think a motion is in order to accept the report as progress.

(A motion was regularly made, seconded, and carried, that the report be accepted as progress.)

The Chairman:—The next report is that of the Committee on Water Power. This is a subject which is of considerable interest, and the Committee each year has made quite a valuable contribution to the literature on Water Power. I am going to ask Mr. W. L. Morse to say a few words about the work.

Mr. W. L. Morse (New York Central):—During the past year the Committee was assigned to report further upon the power of the St. Lawrence River, on the Passamaquoddy Bay and on the Saguenay River, and in addition to what has been given before we have inserted such information as we thought pertinent at this time in this year's report.

In addition to that, we have given some information on the Gatineau River near Ottawa. Representatives have also attended the conference of the Southern Appalachian Power Conference at Chattanooga, Tennessee, and listened to some very interesting information in regard to development of power on the Tennessee River.

It has been reported that Major Harold C. Fisk, of the United States Army, chief of the Tennessee Valley survey, has recently announced a plan that contemplates the building of 100 dams with a possible output of 4,000,000 H.P. on a 400-mile stretch of the Tennessee River, between Paducah, Kentucky, and Knoxville, Tennessee. This is going to open a very interesting field of study for the Water Power Committee, though as yet there is very little that can be said. Muscle Shoals is one power development now on that river, where perhaps we have all thought all the power in the world was located, but which is only about one-fortieth of that river. There are at Muscle Shoals 100,000 H.P. as compared to the possible 4,000,000 H.P. that may be developed on the river.

The report is given as information with the recommendation that the subject be continued.

The Chairman:—You have heard Mr. Morse's outline of the report of the Committee on Water Power. If there is no objection, it is suggested that this report be received as information. Are there any comments? If not, we will assume that it is acceptable to the Association.

The next Committee is that in collaboration with the American Committee on Electrolysis. This is a subject which has not been active during the past year. The Association is represented on the Committee by Mr. W. M. Vandersluis.

Mr. W. M. Vandersluis (Illinois Central):—The Sub-Committee of the Committee on Electrolysis held one meeting since the report of last year. They report having assisted in revising a chapter on stray current electrolysis prepared by one of the members for a book on "Corrosive Engineering," Dr. F. N. Speller.

Considerable attention was given to the various aspects of the Grounding Rules and it was also reported.

The Sub-Committee also criticized and commented on a paper on "Electrolysis Mitigation," by E. R. Shepard, submitted to the Bureau of Standards.

On account of the fact that the two parent organizations of the American Committee on Electrolysis resigned, the question of continuing that committee was discussed. The need of having such a committee to deal with Electrolysis and other related questions and to handle investigations, was expressed by the various representatives. Resolutions were finally passed covering the continuing of the committee and extending invitations to the two organizations which had resigned to return, and to enlarge the committee to include other organizations which were handling allied subjects.

The Committee on Electrolysis submits this report as information with the recommendation that the subject be continued with representation on the Committee on Electrolysis.

The Chairman:—Are there any comments on this subject? If not, we will assume this report will be accepted as information.

The next subject is a very important one: collaboration with the U.S. Bureau of Standards in the revision of the National Electrical Safety Code. Those who are interested here are undoubtedly familiar with the history of that important discussion which is now practically complete. I am going to ask Mr. Morse, who has been handling that work for the Association, to report on the work of that Committee.

Mr. W. L. Morse:—It will be remembered that at last year's session it was reported that a number of the handbooks in that connection had been accepted for different parts of the Code, but in regard to Part 2, power lines crossing railroads, we were in disagreement with the Safety Code and had not seen our way to accept it, having presented a minority report, and we were authorized to undertake negotiations with the National Electric Light Association leading toward an amicable settlement between ourselves. We have progressed so far in that matter that we are now in the process of preparing a set of principles and practices for power lines and have withdrawn our minority report that was placed with the Bureau of Standards, advising them that we would accept the Code but stating our position in regard to those features with which we were in disagreement. This was done in order to better our standing when we have appeared before the various state commissions, when a state undertakes to enact legislation governing the construction of wire lines across railroads. So that, at the present time, the fourth edition of the National Electrical Safety Code has been printed and is in use.

The recommendation of the Committee is that the work be continued in co-operation with the U.S. Bureau of Standards for the revision of the National Electrical Safety Code under the procedure of the American Engineering Standards Committee or any part of the Code that may be reopened for the preparation of specifications for supply lines crossing railroads, and the representatives of the National Electric Light Association in the preparation of a general agreement as to principles and practices with accompanying specifications covering power wire crossings over railroads, to be made the standard of both associations.

The Chairman:—You have heard the report of the Committee in collaboration with the U.S. Bureau of Standards. This is an extremely

important subject, and any suggestions or comments would be very much appreciated by the Committee. If there are no comments, we may assume that the work is satisfactory to the Association and the Committee will continue as heretofore.

The next report is that of the design and construction of catenary-supported working conductors. This with the development of railway electrification, particularly overhead contact construction, which has been quite rapid during the past few years, is an extremely important subject. The Committee has done a great deal of constructive work in compiling the information, and the report is of considerable value and interest.

Mr. L. S. Wells, of the Long Island Railroad, who was Chairman of the Sub-Committee, is unable to be here, and I am going to ask Mr. B. F. Bardo, of the New Haven Railroad, to present the report.

Mr. B. F. Bardo (New York, New Haven & Hartford):—An outline of the work under consideration for this Sub-Committee has been: First, to revise and keep up-to-date the transmission line specifications previously adopted. Second, to continue the study of design and construction for catenary-supported working conductors.

The Sub-Committee submits for consideration its report which may be summarized as follows:

First, consideration has been given to the transmission line specifications previously adopted and there have been no changes or additions recommended during the past year.

Second, the work of Sub-Sub-Committees 1, 2, and 3 in connection with the catenary specifications, has been advanced and co-ordinated. Sub-Sub-Committee 2, with the co-operation of Sub-Sub-Committee 3, has developed a preliminary draft of specifications covering design and construction for catenary-supported working conductors. This draft has been reviewed by the full Committee, following which certain changes and additions have been incorporated. The revised specifications in tentative form are submitted herewith. Their requirements with respect to loading, unit stresses, etc., conform in general with those of the transmission line specifications. The specifications are subject to further revision, particularly such parts as relate to loading, unit stresses and clearances.

It is the feeling of this Committee that further consideration of these features should be deferred until such time as the work of Sub-Committee No. 5, jointly with the National Electric Light Association, in the preparation of wire crossing specifications satisfactory to the railroads, has been concluded.

It is therefore recommended that the subject be continued.

The Chairman:—You have heard the report of the Committee on overhead catenary construction. This Committee's work is rapidly developing to an extent which almost amounts to the compilation of a handbook on the subject, which is quite authoritative. Are there any comments on this subject?

Mr. M. Hirschthal (Delaware, Lackawanna & Western):—I have written the Secretary a letter covering some suggestions, but on re-reading

this report, I find one point which I have not covered in my letter and which I want to call to your attention at this time. It is in connection with Paragraph 13, Loading on Supports. In the third line the statement is made: "On flat surfaces these unit wind pressures shall be increased by 60 per cent." This is somewhat inconsistent in the results that are obtained by applying this 60 per cent correction; in so far as heavy loading is concerned, there is a provision for an 8 lb. per square foot load of wind pressure which is correct for the allowance of greater ice exposure, but for the support there is no such allowance. On the medium catenary loading there is an allowance of 10 lb. and on the light 15 lb. per square foot with the result that after the 60 per cent correction is applied we will have the greatest loading *on the supports* for the light catenary loading; less loading for the medium catenary loading and the smallest load for the heavy catenary loading.

The Chairman:—That is a very important question which was pretty thoroughly discussed, as I understand it, in the Committee. The comment will be referred to the Committee and reviewed very carefully. I think some action will undoubtedly be desirable in following your suggestions. Are there any other comments?

These specifications are published with just this in view, developing comments and suggestions from the members who are interested. If there are no other comments it will be considered that the report is acceptable as information.

The next subject is that of the study of economics of railway location as affected by electrical operation, collaborating with Committee XVI—Economics of Railway Location. This Committee up to date has not been called upon to co-operate with Committee XVI but is holding itself in readiness to do so at any time. It is recommended that the subject be continued. Unless there are comments it will be assumed that that is satisfactory.

The next subject is, "The Standardization of Friction and Rubber Tapes." Some years ago the Committee submitted specifications for friction tape and rubber tape, which were concurred in in co-operation with the Signal Section and the Mechanical Division. These specifications still stand. A few minor changes in wording were suggested during the past year, but it was the consensus of opinion that no changes should be made at this time. If there are no comments it will be assumed that that is satisfactory to the Association and that it is satisfactory to continue the subject and make any changes which may be desirable from time to time.

The next subject is, "The Standardization of Insulator Specifications." This is a vital subject in connection with railway electrification, because insulators, especially with the high voltages which are being employed, are a fundamental factor in successful electric operation.

The Committee has done considerable work in this connection with other organizations as well as presenting the result of its own experience, and the report on insulators is one of the important items of this current year.

I am going to ask Mr. B. F. Bardo, who did much of the work on that Committee, to present the report in the absence of Mr. Hall who is the Chairman.

Mr. B. F. Bardo:—The assignment of this Committee during the past year has been: First, to revise and keep up to date insulator specifications already adopted. Second, to consider the tensile strength of suspension type insulators as measured over a short period of time as compared with the same strength as measured over a long period of time. The work of the Committee may be summarized as follows:

"1. The Sub-Committee is of the opinion that a revision of the insulator specifications is not called for or necessary at this time. The Sub-Committee is represented on and is keeping in close touch with the work of the American Engineering Standards Committee, which has two sectional committees working on insulators. The Sub-Committee recommends approval of the report of the Department of Commerce on One-Piece Porcelain Insulators, presented herewith, in the interest of elimination of waste.

"2. The Sub-Committee has secured a limited amount of information covering the tensile strength of suspension type insulators, and has noted the increase in strength of the newer designs. It is of the opinion that there is not information of sufficient importance before it to justify a report this year.

"Conclusions. It is recommended that this subject be continued."

The Chairman:—You have heard the report of the Committee on Insulators. Are there any comments?

The standardization of one-piece insulators, which Mr. Bardo mentioned, is shown in some detail, and those who are interested will find a considerable amount of information of value. Standardization, especially with such things as insulators, is going to mean many economies and advantages in electrification construction, and the more it is done the better off the railroads will be.

Are there any comments? If not, the next Committee is that of revision of the tables showing third rail clearances and overhead working conductor clearances.

It has been the custom to furnish every alternate year tables showing the practice which railroads have made in clearances for electrical conductors. This year the tables are presented as information without any definite recommendations. The practice of railroads in this respect is of a good deal of interest to those who are charged with the problem of design of catenary third rail construction.

Are there any comments on that subject? If not, it will be assumed that it will be satisfactory to accept it as information and that the recommendation to continue the subject will stand.

The next subject is the protection of oil sidings from danger due to stray currents. That is a subject which was active sometime ago, and specifications for recommended practice were drawn up to guide railroads confronted with the problem of stray currents in making safe construction. So far as is known, those recommendations have been successfully carried

out in most cases, and the Committee has been merely keeping in touch with the situation during the past year, keeping in mind the desirability of possible changes. It is recommended that this subject be continued as in the past, and if there are no comments it will be assumed that that is satisfactory to the Association.

The next subject is that of the study and report on specifications for track and third rail bonds. This is quite an important subject and has meant a great deal of intensive study by the Committee. The report is a valuable one and perhaps the most valuable one which the Committee has accomplished this past year. Mr. J. H. Davis is Chairman of the Sub-Committee, but he was unable to be here to-day. Mr. J. V. B. Duer, the Vice-Chairman, is ill and was unable to come. I am going to ask Mr. Gordon, of the Pennsylvania Railroad, to present the report on the track and third rail bonds.

Mr. K. H. Gordon (Pennsylvania) :—The Committee for Specification of Track and Third Rail Bonds was assigned five subjects to cover during the past year. They were as follows:

1. Developing a standard specification for measurement of bond resistance.
2. Securing data on current carrying capacity of bonds.
3. Study of details of bond design with a view to developing specifications covering the different classes of bonds.
4. The effect of heat of welded bonds on track rails, co-operating with the Rail Committee.
5. Means of attaching bonds to manganese track rails.

With regard to the first of these subjects, a specification for the measurement of bond resistance has been prepared and is included in the report of the Committee.

The second item was given considerable study and it was finally decided that reliable figures would be difficult to obtain, and it is suggested that the study of the subject be discontinued.

The other three items are covered in considerable detail in the report, and I shall not attempt to discuss them at the present time.

The recommendations are that the subject be continued with special reference to the following items:

1. Study of details of bond design with a view to developing specifications covering the different classes of bonds.
2. Collection of information as to methods and extent of practice in re-applying bonds.
3. Collection of data on compositions used, if any, on rail joints to replace bonds.
4. Study of contact areas and resistances for different types of bonds.
5. Compiling information concerning rail joint clearance and its effect on rail bond design.

The Chairman:—You have heard the report of the Committee on Rail Bonds. Are there any comments?

If not, it will be assumed that this report is acceptable to the Association.

The next report is that of the Illumination Committee. That Committee has done a considerable amount of work in standardization of lamps and also in floodlighting large classification yards, which is, as you all know, an extremely important subject from various angles.

Mr. E. B. Katte, who is Chairman of that Committee, is, as I said a little while ago, not able to be present, and I am going to ask Mr. Kutner, one of his assistants, to present the report on Illumination.

Mr. S. D. Kutner (New York Central):—The Sub-Committee has reviewed and revised the Tungsten Lamp Schedule as it appeared in Bulletin 291 of November, 1926, as indicated in the schedule of Incandescent Lamps. These changes, primarily, consist of increasing the voltage of cab lamps from 33 to 34, and permitting the use of 34-volt lamps for headlight service. A 60-watt, 32 or 34-volt, P-25 bulb for headlight service, was added to the list. The G-18½ bulb, in the 23 and 36-watt lamps in headlight service, street railway lighting service, has been changed to the new manufacturers' standard, A-19. These changes have been made to correspond with the Incandescent Lamp Schedule recommended by the Mechanical Division of the American Railway Association.

The Sub-Committee, appointed a year ago to investigate the matter of floodlighting of railway yards, finds it possible to submit only a progress report this year. Certain desirable data are not yet available, and the Sub-Committee has, therefore, revised the program of work developed last year.

The Committee recommends that the schedule of incandescent lamps presented on page 319 be accepted as recommended practice and the subject continued. It is not recommended that the list be now printed in the Manual, on account of probable changes in the near future. Also, the Committee recommends that the study of floodlighting be continued.

The Chairman:—Are there any comments on the report of the Committee on Illumination? It is hoped that during the coming year more information will be available and more quantitative standardization possible on floodlighting illumination than is at present the case. If there are no comments, it will be assumed that the report is satisfactory.

The next Committee report is that on the study of the design of indoor and outdoor substations. This report is one of the most interesting, I think, that the Committee has made this past year. It is quite a voluminous one and represents a large amount of work. Mr. Duer, who is Chairman of the Committee, is not present, and I am going to ask Mr. Vandersluis, the Vice-Chairman, to present the report.

Mr. W. M. Vandersluis (Illinois Central):—The Committee felt that its work should cover the following:

1. Determine conditions affecting selection of indoor and outdoor types of station.

2. Determine applicability of various methods of controlling substation and equipment as follows: manual control, remote control, supervisory control, semi-automatic control, and automatic control.

3. Study and report on present development and major considerations in selection of: circuit breakers, air brake switches, transformers; synchronous converters, motor generators, synchronous condensers, static condensers, mercury rectifiers; protective devices—relays, and lightning arresters; meters and meter transformers.

4. Design best fitted to obtain a maximum of safety and continuity of service during maintenance and repairs, and operation.

5. Miscellaneous important questions such as:

(a) Tabulation of minimum clearances between conductors, and conductors to ground for various voltages, both indoor and outdoor.

(b) Tabulation of adequate insulation, phase to phase and phase to ground, for various voltages, both indoor and outdoor.

(c) Study of permanent and emergency grounding practices.

(d) Study of possibilities in unit type of construction as applied to substations.

There is presented, closely following this outline, a discussion which is offered as information with the recommendation that the subject be continued.

The Chairman:—You have heard the report of the Committee on Substations. Are there any comments or criticisms?

This subject, like that of the catenary construction, is developing almost into textbook form. It is going to provide, I think, a valuable addition to information and recommendations in connection with the increasingly important subject of railway electrification. If there are no comments, it will be assumed that the report is accepted.

The next subject is that of the design and specifications for high tension cables. This subject is a relatively new one, and Engineers do not agree entirely on what a cable should look like. The report is quite a preliminary one because the subject was started only recently. It consists of the following subjects:

(a) Collecting information relative to cables now in service.

(b) Collecting information having a bearing on the subject from publications, from other societies, and from manufacturers.

(c) Determining on a form on which to tabulate the information.

This last item is pretty nearly as important as the other subjects, because information is so voluminous and there is so little agreement among those who are authorities on the subject.

It is recommended that this subject be continued during the following year.

Are there any comments on the report? If not, it will be assumed that it is satisfactory to continue.

Another subject, a new one, which the Committee feels should be studied, is that of the application of non-corrosive materials to railroad

electrical construction; not only electric traction, but all electrical construction.

The Committee recommends that that subject be taken up for study. If there are no objections or comments, it will be assumed that it is satisfactory to the Association.

That completes the list of committee reports, with the exception of the report of the Committee on the Manual, which has been saved until last because some of the other reports refer to the Manual.

I am going to ask Mr. Vandersluis of the Illinois Central, who is the Chairman of the Committee on the Manual, to make a report.

Mr. W. M. Vandersluis:—The Committee on Illumination recommended that the Schedule of Incandescent Lamps presented be accepted as recommended practice and the subject be continued, but they do not recommend that this schedule be now printed in the Manual on account of the probable changes. There is, however, a schedule in the Manual which should be removed. I therefore recommend and move that there be removed from the Manual the 1926 tungsten lamp schedule as approved at the Annual Meeting in March, 1927, Appendix M, pages 128-131.

(The motion was seconded and carried.)

The Chairman:—I will now review, hastily, the recommendations which have been made for new work. Some of those have already been included in the Committee report, but it may be of interest briefly to go over the situation and to include one or two other suggestions which have not been mentioned. These are printed in general on page 257 of the Bulletin.

(The Chairman read the recommendations for future work.)

The Chairman:—I might say to those who are not familiar with the subject that we have two representatives in each state in the Union who are charged with the duty of advising the Association of any action which may be taken by public regulatory bodies in connection with specifications for transmission and distribution line construction, in order that if necessity arises the American Railway Association may be represented at any hearings and may assist in looking after the interests of the railroads.

An additional subject which has just been mentioned is the application of non-corrosive materials to railway electrical construction. Are there any comments on that item for the work of the coming year? If not, I suggest that the recommendations are before you and it is in order to authorize the Committee to follow the program.

(The motion was seconded and carried.)

The Chairman:—That concludes the report of the Electrical Section. I thank you.

Mr. W. L. Morse:—Mr. Chairman, this having been the annual meeting of the Electrical Section, I move its adjournment.

(The motion was seconded and carried.)

(Mr. D. J. Brumley, the President, resumed the Chair.)

The President:—I believe it would be proper at this moment for the American Railway Engineering Association to accept the report of the Committee on Electricity which has just been presented in the annual report

of the Electrical Section. The Chair will entertain a motion to that effect.

(A motion was regularly made, seconded, and carried, that the report of the Committee on Electricity be accepted.)

The President:—I wish to call your attention to the vast amount of work that the Committee has laid out for itself next year. There are a great many things to be worked out in connection with the electrification of railways. We have a group of men so much interested in this matter that they are willing to take their own time and use the effort to prepare some written reports of great value to the Association. If there is nothing further, the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON SIGNALS AND INTERLOCKING

(For Report, see pp. 675-706)

(Mr. C. H. Tillett, Past-Chairman, Signal Section, A.R.A., in the Chair.)

Mr. C. H. Tillett (Past-Chairman, Signal Section) :—Before asking Mr. Post, the Chairman of the Committee, to proceed with the report, I want to take this opportunity of thanking you for the courtesy extended to the Signal Section by asking the immediate Past-Chairman to preside over a meeting of this Association. I am sure it is a courtesy that is appreciated by the Signal Section and will go far to help remove the feeling that seems to exist in the Signal Section that after all they are only a stepchild of Division IV—Engineering, and I believe makes us appreciate more that we are a part of the family.

At our meeting at the Stevens Hotel yesterday and the day before, there was a very fine exhibit placed in the corridor of the room on the third floor, and it has been arranged to carry it over until to-day. This exhibit consists of a number of pictures that were at the Baltimore & Ohio Centennial, which have been arranged in very good order. We would like as many of the A.R.E.A. membership as can get over there to take the time to look at them, because we feel they are quite worth while.

Our meeting yesterday and day before kept a considerable number of Signal Engineers from being present at the opening of this Association yesterday. We were prevented from hearing the President's address, a fact which we lament to a considerable degree. We hope, sometime in the future when we get a little better acquainted, to convince the membership of the A.R.E.A. that Signal Section meetings are of sufficient interest that they would desire to attend them, and in that way perhaps we can work out an arrangement between the two organizations that will prevent this overlapping of meeting days.

I again take the opportunity of thanking you for this privilege, and call on Mr. Post to present the report.

Mr. W. M. Post (Pennsylvania) :—The Committee submits a report on the following assignments:

Continue study of automatic train control, collaborating with Committee V—Track and Committee XIV—Yards and Terminals.

Continue study on automatic manual and non-operative signals for highway crossing protection, collaborating with Committee IX—Grade Crossings.

Prepare and submit as information a synopsis of the principal current activities of the Signal Section, American Railway Association, supplemented with list and reference by number of adopted specifications, designs and principles of signaling practice.

These three reports are presented as information. The first report, "Study of automatic train control," will be found in Appendix A on page 642. This report was prepared by a Sub-Committee, of which Mr. G. E. Ellis is Chairman. Mr. Ellis, as you all know, is Secretary of the Com-

mittee on Automatic Train Control of the American Railway Association. He keeps both the Signal Section and this Association advised as to the activities of train control throughout the country. I am sorry Mr. Ellis is not here this morning to handle this report.

I will read a few paragraphs from his report.

No additional roads have been required to install train control since the last report, but a considerable mileage above that required by the orders of the Commission has been installed or is under construction on several different roads which already had complied with the orders. A number of orders have been issued permitting various roads to operate non-equipped branch line locomotives of their own and tenant lines over short stretches of equipped track, generally less than five miles in length.

In addition to omission of the requirement that required a displacement checking device on certain devices in the reports on the various installations, the Commission has definitely, by formal order, permitted the Chicago, Rock Island & Pacific Railway to remove the displacement detectors from their ramps. There has been no change, however, in the general requirements under which these displacement detectors were first required.

Exhibit A, which is found on page 644, gives the mileage as last reported for the first and second orders, together with the number of locomotives as of September 1, 1927. It will be noted that in some cases all the locomotives required for both orders are included in the first order. These figures have been compiled from records of the Committee on Automatic Train Control of the American Railway Association.

Additional inspections are made of the permanent installations as soon as they are completed and in operation. As of September 1, 1927, 38 inspections have been made on the first order, and 19 on the second order. Inspections have also been made of some of the voluntary installations referred to in a previous paragraph. Reports have been issued by the Commission on 49 inspections. Exhibit B, which is found on pages 645 to 658 inclusive, gives an abstract of the exceptions, requirements, recommendations, etc., made in each of the reports issued since the list published in Exhibit C of Vol. 28. These have been arranged in the order as issued by the Commission and not according to devices. The first and second orders are grouped separately.

This information is assembled in this way in order that roads making installations of automatic train control may know what to avoid by reading the exceptions and requirements of installations that have already been placed in service.

The Committee on Automatic Train Control of the American Railway Association is continuing its study on accidents as reported by the Commission, but the work has not been completed and no information is available at the present time.

I have just been advised that this report has been finished and no doubt will be given at the next meeting.

That completes the report on that assignment.

The report on the second assignment, "Study on Automatic Manual and Non-Operative Signals for Highway Crossing Protection," will be found in Exhibit B on page 659. I will ask Mr. A. H. Rudd, the Chairman of this Sub-Committee, to present this report.

Mr. A. H. Rudd (Pennsylvania) read the report of the Sub-Committee to "Continue Study on Automatic Manual and Non-Operative Signals for Highway Crossing Protection," with the following interpolations:

No. 1, page 660: Preceding Paragraph 4 of the report, Mr. Rudd said:

"The recommended standard of the American Railway Association is a white disc with black cross, similar to the approach sign already made standard by this Association."

No. 2, page 660: Preceding Paragraph No. 10 of the report, Mr. Rudd said:

I will not read that, but in effect the railroads of Pennsylvania and the Highways Department of Pennsylvania have reached an agreement which has been approved by the Public Service Commission of the State, in which at all crossings of state highways with the railroads, where the Public Service Commission considers protection is required, and agrees that sufficient protection is given by installation of automatic signals, the alternating flashing light signal is made standard by the Public Service Commission of Pennsylvania. The railroad will erect, and the highway will pay one-half the cost of erecting; the railroad will operate and maintain.

At points where the signal cannot be seen 500 feet, the Highway Department will erect a yellow flashing light, the railroad will pay one-half the cost of installation, the highway will operate and maintain.

Where the grades have been separated, either overhead or underneath, and the curves approaching such grade separations are sharp, the Highway Department will erect yellow flashing lights approaching the curves, and the railroads will pay half.

You all know that in New York state they have a big bond issue, and the state is going to help the railroads on grade separation. In many states the cost of grade separation is divided. In New Jersey the grade separation must all be paid for by the railroad, but Pennsylvania is the only state so far as I know where there has been an agreement that the municipalities or the state will pay a part of the cost of the grade crossing protection, and it seems to us there is a great field there for a fair division on the basis that the railroads have not rendered the crossings more dangerous. It is the great number of automobiles, and it is only fair that the public should pay part.

No. 3, page 662: Preceding Paragraph No. 1, Mr. Rudd said:

In that connection there has developed in the last couple of months a strong agitation in Washington before Congress and before the Interstate Commerce Commission on account of the great number of casualties at grade crossings, for the erection of gates, particularly automatic gates, and the special committee on Highway Crossings of the Signal Section will

investigate that phase of the situation this year. It is possible that something of that kind will have to be provided in order to satisfy the public clamor.

In connection with that, Mr. Maro Johnson just handed me this. Perhaps he wanted to present it with his report, or may I use it:

"A bill introduced in the House by Representative Newton, of Minnesota, proposed the appointment of a Board of Engineers to select the most practical device for the prevention of grade crossing accidents and to supervise the testing and installation.

"This Board is to have five members, two appointed by the Interstate Commerce Commission Committee of the Senate and the remaining three by the Interstate and Foreign Commerce Committee of the House.

"The Bill provides that after the most practical appliance has been selected and tested the Board shall supervise the installation on the railroads, requiring them to install a certain percentage of their total mileage each year and imposing fines in case of delay or failure."

That is a starter.

No. 4, page 663: Preceding Paragraph No. 5, Mr. Rudd said:

We would like to qualify that statement by not saying it is questionable, but saying that it is bad practice. The United States Supreme Court recently ruled that the responsibility was on the driver to stop, look and listen if necessary. Anything that the railroads give in the way of a green "Go" signal to encourage people to cross is a bad proposition. In the first place, we may have a false clear signal, or if there is any accident the railroad, as we see it, assumes the responsibility by inviting the traveler to cross, and renders itself liable to heavy damage.

On the other hand, we all know that the driver who gets the green light in the city speeds up so as to get across before the light changes to red. If that is done at railroad grade crossings it encourages fast driving over the railroad crossing, causes men to become injured and to violate the state law.

No. 5, page 663: Preceding Paragraph No. 7, second section, Mr. Rudd said:

In addition to that, the American Engineering Council is also actively at work and has made its report, and in almost every case there is just enough difference in the suggestions to ruin any chance of standardization. Each committee has a little improvement to make on that of some other committee and the result will be chaos unless there is some way of coordinating the entire subject.

No. 6, page 664: Preceding Paragraph No. 8, Mr. Rudd said:

For signs of white background and black letters. The Hoover Conference and the American Engineering Council have recommended for the stop sign the octagon, yellow background and red letters. That was also recommended by the Committee on Code of Colors for Traffic Signals but was turned down by the Highway Association, and that held up the adoption of the Code for over a year. I presume eventually there will be a

compromise so as to get some red on the stop sign for the reason that a great many cities require it.

No. 7, page 664: Preceding Exhibit A, Mr. Rudd said:

Exhibit A which follows is what is known as an American Standard, and you will note on page 666, Section 4, Signals at Railroad Grade Crossings, up to Section 5, Specifications for Colors, the exact specifications of the Signal Section and of the A.R.E.A.

Mr. W. M. Post:—The Committee invites discussion of this report. Mr. Rudd will be glad to answer any questions or give any further information.

Mr. A. H. Rudd:—I might say at the bottom of page 667 that the light and dark limits adopted as the American Standard for the colored lights are lighter in every case than those which are standard for railroad signals, and it is possible that the green is somewhat too light and would fade out. That is done so as to give a greater range.

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—Mr. Rudd made the statement that Pennsylvania is the only state in which by law, the division of cost of grade crossing protection has been divided between the railways and the public. At least I understood him to make that statement.

Mr. A. H. Rudd:—I said there were a number of states where provision is made. In some cases the amount is specified. In many others it is placed in the hands of the Public Service Commission to allocate the cost for grade separation.

I said that Pennsylvania was the only state I knew of, and I am quite sure it is the only state in the Union where provision has been made for dividing the cost of grade crossing protection, not separation—protection.

Mr. O. E. Selby:—If I used the word "separation" I did it inadvertently. I was speaking to the subject of grade crossing protection. The state of Michigan recently has passed a law making it possible to divide fifty-fifty the cost of grade crossing protection.

Mr. A. H. Rudd:—The Committee is glad to get that information. I might say that it is not the law of Pennsylvania. There is no law in Pennsylvania providing for the allocation of costs in grade crossing protection, but the Highway Department made this agreement with the railroads and there is nothing in the law to prevent the Public Service Commission from approving such an agreement, although they cannot primarily, of their own initiative, and cannot require any division of costs between the railroads and the highways. It is simply an agreement.

Mr. Robert H. Ford (Rock Island):—The Committee has presented some valuable and interesting information on one of the most important subjects before this Association.

This Committee is required to collaborate with the Committee on Grade Crossings and although the report does not so state, it is to be hoped that they have done so.

Apportionments of cost are economic and I do not share the views expressed by the Committee with respect to same.

Because it has been necessary to temporize with the situation, these conditions are largely of an arbitrary character and not on the benefit basis, which is the logical and proper method for spreading the cost of these improvements. It is because the interested parties have not yet been able to arrive at a proper understanding of the principles involved, that the existing practice of arbitrary apportionments are being continued.

On page 663 of the report, it states "it is questionable whether it is good policy for the railroads to give a "Go" signal to highway travelers over the crossing with the railroad." It is not questionable. It is dangerous and decidedly bad practice.

The United States Supreme Court (Justice Holmes speaking) has stated:

> "When a man goes upon a railroad track, he knows that he goes to a place where he will be killed if a train comes upon him before he is clear of the track. He knows that he must stop for the train, not the train stop for him. In such circumstances, it seems to us that if a driver cannot be sure otherwise whether a train is dangerously near he must stop and get out of his vehicle, although obviously he will not often be required to do more than stop and look. It seems to us that if he relies upon not hearing the train or any signal and takes no further precaution, he does so at his own risk."

This Association should do nothing that would weaken this responsibility. Rather they should help by co-operating with and through the other railway organizations concerned with the subject in the proper education of the public that they jointly with the railroads are responsible for safety at public road crossings.

On page 659 of the Committee report, it is stated "the railroad standard highway crossing sign," etc. It is to be deplored that there is not yet a standard railway crossing sign. The Committee on Grade Crossings has developed that out of 28 states (58 per cent) reporting, there are 14 different types required by the state laws.

Information is not available of the requirements in the remaining 20 states (equaling 42 per cent), but it is a fair assumption that there is approximately the same difference, which would mean approximately 24 variations required by state laws for the country at large.

Truly a chaotic condition and especially so when it is remembered that upon the railways has been unjustly placed the burden of responsibility for railway grade crossing accidents. It is therefore not surprising that the user of the highway who under modern practice has now become a traveler through a number of states within the same day, should become confused over the type and character of "legalized" protection.

It is to be hoped that the Grade Crossings Committee and the Committee on Signals, working together, will be able to find some means of bringing this to the attention of the Association by resolution or otherwise, in such a way that a standard railway crossing sign may ultimately be adopted and the Federal and State practice altered in such a way as to conform therewith.

With respect to the question of lights. I trust the Committee will also give consideration next year to the desirability of taking a strong definite position with respect to the use of red lights as a danger signal at and in the vicinity of highway crossings, and this applies with equal force to the use of red lights at garages, particularly in the vicinity of railroad tracks and railroad crossings. Garages as a rule use red lights to mark their entrances, although the blue light has been recommended in some cities for this purpose. There ought to be a very definite pronouncement from this Association with respect to the use of the red light as a danger signal, irrespective of its location.

I hope also that this Committee, as well as the Committee on Grade Crossings, will give joint consideration to the approach warning sign, both as to form and manner of lighting if and when this should be necessary. Also, that this Committee will give consideration to the use of reflecting glass, of which there are a great many varieties for use on advance warning signs, danger signs and stop signs on highways in the vicinity of grade crossings.

The railroads are being improperly placed in a defensive position on this question of grade crossing protection and until, through co-operation and sympathetic understanding, a common ground has been reached, the traveling public, as well as the railroads, are the principal sufferers. We owe it to them as well as to ourselves that every effort be made to secure definite reports upon these important questions.

Mr. A. H. Rudd:—Answering a few of the points made by Mr. Ford, the question of grade elimination is not the province of this Committee at all, and I only mentioned it to draw the comparison between the laws which provide for grade separation and the division of cost and the lack of such division of cost in regard to grade crossing protection. The Committee on Grade Crossings and the Committee on Signals and Interlocking are instructed to cooperate, and we did it in a novel way.

The instructions of the Committee of Direction were indefinite, and each committee was waiting for the other committee to invite it to meet with the other committee. The net result was that the Committee on Grade Crossings made its report and submitted it to the Sub-Committee of the Signal Section of the Committee on Signaling. We made some suggestions, and then found it was too late to make any changes. We made our report and I do not think we submitted it at all. In that way we got perfect agreement. There was no discussion of it in any way at all, and each report was unanimous, but they differed from each other.

Mr. Johnson and I have a little date with each other immediately after this hearing, and I think we can get cooperation, provided the Grade Crossings Committee will agree with us.

Recently I was appointed on the Committee of the American Engineering Council, which had no railroad representative and I have recently received their preliminary report. That is another case where we got in a little bit late. The report has been made, and they have made some errors, providing that the railroad crossing signs shall be circular and

located within 100 feet of the railroad. They evidently did not know anything about the crossbuck at all. I explained the approach sign, etc.

I can assure you of one thing, and that is if you all read this report —I suppose you all have—on Code on Colors for Traffic Signals you will find that the whole thing is based on red for danger. The Hoover Conference had that same thought. The American Engineering Council is the Sub-Committee on Plans and Signals of the Hoover Conference. They have insisted on red as the danger signal, and it must be so respected. The provision for highway crossings, one crossing of a highway over another, requires that the traffic lights shall be yellow for "Caution," the green for "Go" and the red for "Stop."

It also provides that there shall be no changes from red to yellow to green, but that when the signal displays green and they are about to change to red, the yellow shall be displayed first, as a preparatory signal, and that during the display of either the green or the yellow, the signal on the cross street shall be red, and when the signal changes from red, the change is immediately to green. On the basis that the yellow is a cautionary and not a change signal and that changing from red to yellow before they go green is a temptation for the drivers to beat the green. All through travel and also the turns should be made on the green, except in special cases where it should be bulletined. I think they had in mind the turns from Michigan Boulevard to the cross streets where it would appear the turn on red is good, but on all other cases the turns would be made on green, nobody is to be permitted to proceed on red.

That principle has been driven into all these associations so that I think we are very safe on that particular point.

The report of this committee also provides and suggests the illumination of grade crossing signs, both the approach sign and the others, and suggests various ways of illumination, and this committee has been studying for some time the question of self-illumination of these signals.

Mr. Robert H. Ford (Rock Island):—In view of the remarks of the Chairman of the Sub-Committee, it is to be hoped that the paragraph on page 663 will be rewritten in harmony with his expressions.

Mr. A. H. Rudd:—We have already done it while you were talking and the Committee submits this instead of the first paragraph on page 663. That represents not only this Committee's idea, but it represents the almost unanimous idea of the Special Committee on Highway Crossing Protection.

"It is not good policy for the railroads to give a 'Go' signal to highway travelers over the crossing with the railroad, and it should not be permitted."

Mr. W. M. Post:—Mr. Ford has suggested several lines of discussion. I can assure the membership, however, that it is the desire of this Committee to cooperate in every way possible with any of the committees of the American Railway Engineering Association. Developments in railway crossing protection have been very rapid. A great many different bodies and associations are working on this question. Sometimes it may be best to go slowly. We will endeavor to keep the Association advised of all the

developments that we think will be helpful. I would suggest that we have further discussion.

Mr. A. H. Rudd:—I might say personally it would have been easier for me if Mr. Ford had made that motion. Perhaps he will yet. I have just been through a session of preparing evidence to present to our people, to tell them why we should not do it. I think they are convinced, although I have not yet presented the report, but if I go back and say that the American Railway Engineering Association passed a vote this should not be done, they may want to know who made the motion and if I tell them I did, they may think it was set up in some way.

The situation as I get it, and there is a lot I don't get, is in Orlando, as was stated, they put green for "Go" on railroad signals. I believe the Southern Railway has installed a number of similar signals, the red and green traffic signals. If we pass this resolution, we will discredit that practice. There are isolated cases in cities where the city authorities have practically required the railroads to install the same sort of a signal that they have for their cross streets, and in some cases the railroad has done it.

In the case of the Pennsylvania, we have had two or three places where they wanted joint operation. In those cases we have arranged so that either the train or the crossing watchman will set the signal at stop. After the train has passed, the mechanism for changing the signal to green is set so that the signal may be changed to green by the traffic officer or by the city's automatic devices, but the railroad itself is not a party to changing that signal to green.

It would be helpful to the Committee if the representatives of the railroads here that are making a practice of giving a "Go" signal to highway traffic over grade crossings, would so indicate. I believe they are in a tremendous minority.

Mr. Chairman, as this report is submitted for information only, it would appear that no motion is necessary on the question raised by Mr. Ford, but the Committee will make the change so that when this is printed, that sentence will read: "It is not good policy for the railroads to give a "Go" signal to highway travelers over the crossing with the railroad, and it should not be permitted," as the presentation of opinion of the Committee and as information.

If you want to have definite action, separate from accepting this as information, the Committee will be very glad to have it and get the sense of this Association.

Mr. Louis Yager (Northern Pacific):—In view of the discussion that has been had, I think it is due the Committee that the Convention register its views on this subject, and therefore I move that the revision suggested by Mr. Rudd be approved as indicating the sense of the Convention on this subject.

The Chairman:—You have heard the motion, gentlemen, and it is seconded. Is there any discussion?

(The question was put to a vote and carried.)

Mr. W. M. Post:—The report on the third assignment, "Prepare and Submit as Information a Synopsis of the Principal Current Activities of the Signal Section, American Railway Association, Supplemented with List and Reference by Number of Adopted Specifications, Designs and Principles of Signaling Practice," will be found on page 668. Mr. W. M. Vandersluis, who is Chairman of the Sub-Committee, prepared this report and I will ask him if he will present it.

Mr. W. M. Vandersluis (Illinois Central):—In view of the lateness of the hour, I simply wish to call your particular attention to the principal activities of the Signal Section on pages 668 and 669. There is a digest of the Signal Section Manual listing the specifications, rules, reports and principles on pages 668 to 674. On account of the large number of standard drawings, reference only is made to the standard drawing section of the Manual. The Manual index of drawings covers about thirty-three pages. It was thought best not to introduce them here. This report is submitted as information.

Mr. W. M. Post:—If there is no discussion this completes the reports of the Committee. The assignments for next year are shown in a recommended outline of work on page 641. It is the purpose of the Chairman to suggest to the Secretary, on a suggestion that he has received from one of the members, an additional assignment in connection with increased efficiency by operation by signal indication in lieu of train orders or timetable superiority. Briefly, that will be a description of operating benefits derived from a system known as the train dispatchers' control system, also operating advantages of the control manual block system, and there may be other methods of operation which apply particularly to the single-track lines and in some cases to operation of trains against the traffic on multiple lines where trains are moved by signal indication in lieu of train orders and timetable superiority. The Signal Section has done considerable work along those lines. Committee X will study this question and try to bring something before the Association next year. This completes the work of the Committee.

Mr. C. H. Tillett:—The President informs me that a motion is not necessary unless there is some stated objection to the report being accepted as information.

The President:—We are very much obliged to the members of the Signal Committee for the excellent report presented to the Association this morning. It is very gratifying to note that they have indicated a desire and wish to amplify the work of the Committee next year and bring you reports on subjects which have not been heretofore reported.

This Committee is excused with the thanks of the Association for the excellent work it has done this year. (Applause.)

DISCUSSION ON YARDS AND TERMINALS

(For Report, see pp. 397-438)

Mr. J. E. Armstrong (Canadian Pacific):—At this time your Committee reports progress on one assignment, submits reports as information on two assignments, makes final reports on two assignments, recommends three revisions in the Manual, and submits recommendations for future work.

On pages 397 and 398 of Bulletin 302, there is a statement of the collaboration between this Committee and other standing committees of the Association.

In collaboration with the Committee on Buildings, this Committee recommends, on page 399, that the wording of paragraph 30, in the Passenger Terminals portion of the Manual, be revised from the present form, "The gradient for passenger ramps should not exceed 10 per cent," etc., to the proposed form, "The gradient for passenger ramps *preferably* should not exceed 10 per cent," etc., and that paragraph 40 be revised from the present form, "A gradient of 6.5 per cent is the steepest yet used to any extent for trucking ramps in large passenger stations," to the proposed form, "A gradient of 7 per cent is the steepest yet used to any extent for trucking ramps."

I move that this recommendation be approved.

The President:—It is moved and seconded that the proposed form be approved for publication in the Manual. Is there any discussion?

(The motion was carried.)

Mr. J. E. Armstrong:—In connection with Scales, this Committee, for the reasons stated on page 399, concludes that "when cars are to be weighed in motion, each car shall be entirely and alone on the scale a minimum of four seconds," and that "in all parts of the Manual where reference is now made to a three-second minimum weighing time, the value be changed to four seconds."

Mr. President, I move this recommendation be approved.

Mr. G. D. Brooke (Chesapeake & Ohio):—I should like to ask for information right there. Does that apply to plate fulcrum scales as well as other scales?

Mr. J. E. Armstrong:—Yes.

Mr. G. D. Brooke:—What speed would that give for a big plate fulcrum scale?

Mr. J. E. Armstrong:—I will ask Mr. Roeser to reply to Mr. Brooke.

Mr. H. M. Roeser (U. S. Bureau of Standards):—The speed could be calculated from the length of scale. It would be a lead-pencil calculation. You know the length of the rail, you know how fast it would travel to get across the scale in two seconds. It would depend on the length of the car, too.

Mr. G. D. Brooke:—If this recommendation is adhered to, you cannot improve the capacity of your hump by improving your scale, can you?

Mr. H. M. Roeser:—Yes, I think so. I do not believe the weighing time is anything that cuts down the operation of your hump. It is too

small a portion of the time that is required to get cars over the hump. If you were humping cars to conform to this weighing time, you would be shooting cars over the hump at fifteen cars a minute. That is faster than anybody can move cars. As a matter of fact, I believe two or three cars a minute is as fast as you can go. With this weighing interval of three seconds or four seconds, or even six, it is not going to affect the hump operation any.

The President:—Is there any further discussion? The question is on the adoption of the conclusion at the bottom of page 399.

(The motion was carried.)

Mr. J. E. Armstrong:—The report on Passenger Terminals will be presented by the Sub-Committee Chairman, Mr. H. L. Ripley.

Mr. H. L. Ripley (New York, New Haven & Hartford):—The Sub-Committee had two assignments in connection with Passenger Terminals; first, joint passenger terminal agreement. That will be considered in co-operation with Committee XX, which Committee reported yesterday morning. Committee XX is not prepared to submit its report for final adoption but hopes to do so at the next convention in 1929. This Committee will continue to co-operate with them in perfecting the form of agreement.

The new work submitted to this Sub-Committee had to do with Sub-Terminals. There is presented this year as information only a report on sub-terminals; co-ordination of steam railway and motor bus transportation terminal facilities.

Since this report was prepared, the railroad interests having to do with highway transportation have been formed into a Division of the A.R.A. and presumably will give intensive attention to matters having to do with transporting railroad traffic over the highways in the immediate future. This Committee, as I said before, presents this report for information only and has drawn no conclusions and makes no recommendations.

The President:—If there is no objection, this report will be received as information.

Mr. J. E. Armstrong:—The report on Freight Terminals will be presented by the Sub-Committee Chairman, Mr. L. L. Lyford.

Mr. L. L. Lyford (Illinois Central):—The assignment of Sub-Committee 3 of Yards and Terminals Committee was to continue the study of the design and operation of freight terminals, with particular reference to convenience and economy of operation. After some discussion the Committee chose for its particular study the possible arrangement of units found in large classification yards. The report consists of a suggested arrangement for a generalized type of large hump classification yards. The report is found beginning on page 409 of the Bulletin.

As the volume of freight traffic entering and leaving our large cities continues to increase, there is created a need for larger and a more comprehensive type of classification yards. When the number of cars to be handled is comparatively small, the simple type of flat switching yard works out satisfactorily, but there comes a time in the operation when the number of cars handled and the engines working are such that some other method

of classifying has to be found. There is a trend in the direction of these large hump classification yards.

The general principles that govern the design of these yards have been well tabulated and set out in previous reports of the Committee. Our work this year has been an attempt to apply these principles to a particular yard or a particular problem. The Committee recognizes the fact that every freight yard or freight terminal is a problem in itself, in that certain commodities must have preference in handling, and probably will require special facilities and special features in order to give them that special treatment. We do not contend or think that it is possible to design a yard that can be considered a standard, really, because of the different conditions and the different problems which have to be solved by each railroad engineer.

Generally speaking, few of these large classification yards have been constructed in the United States and Canada, but the design submitted is based on experience and the results obtained in the operation of some of the yards now in service. The plan and descriptive material is submitted with the thought that the information will be of value in connection with the revamping or redesigning or the building of new yards, and is presented to the Association merely as information.

The President:—Is there any discussion on the Sub-Committee's report? If there is none, this report will be accepted as information.

You may proceed, Mr. Chairman.

Mr. J. E. Armstrong:—The report on Driveways will be presented by the Sub-Committee Chairman, Mr. C. H. Mottier.

Mr. C. H. Mottier (Illinois Central):—This subject is of interest to the railroads because of the general use of large trucks in team-track and freight-house driveways, and the tendency of the modern truck to obstruct the driveways.

The report is divided into two parts, the first dealing with team-track driveways, and the second with freight-house driveways.

The Committee pursued three lines of investigation in arriving at its conclusions:

(1) Existing driveways were studied to determine the influences that should be given consideration in determining the desirable width of driveways.

(2) The trend in the use and length of motor trucks used in team tracks was studied with a view of determining the probable future length of trucks that will use team-track driveways and for which the driveways should be designed.

(3) Information was collected as to the present tendency among American railways in the design of team tracks.

The Committee endeavored to locate team tracks with very dense traffic, our idea being to study the operation on those team tracks and if possible to establish a relation which exists between the width of driveway and the amount of delay to vehicles on the driveway.

Twenty-six team tracks in thirteen different yards were studied. The resulting information is shown in Table 1 on page 420.

The observations are reduced to a common basis in the last column of the table. We found that the delays are not uniform. Reasons for this lack of uniformity are outlined in the report. Speaking generally, it might be stated that driveways up to twenty-four feet in width have very heavy delays. From twenty-four to thirty feet the delays are rather pronounced, but they do not vary according to any fixed law. From thirty feet on up the delays are infrequent.

The report also points out that there is not as much traffic normally in a team track as might be supposed and the reasons for this situation are presented. Information is presented on the relation between the angle of loading of trucks and the occupation of driveways, and the effect of team-track driveway widths on costs and space occupied.

The result of the first phase of our investigation led to the fundamental conclusion that it does not seem wise to recommend a width of driveway determined by providing a straight clear driveway between trucks backed up simultaneously on opposite sides of the driveway.

In other words, our conclusions are based on having one truck backed up to one side of a team track with sufficient space in front for a single line of traffic.

With this established, it next became necessary to decide on the length of the truck. A similar study was made by one of the large railroads here in the city in 1920 and 1921, and a comparison of that information with similar information which we collected in 1927 is shown in the report.

Information obtained from various sources on the percentage of trucks of various sizes and the tendency for trucks to replace horse-drawn vehicles is also presented.

A committee composed of representatives of the principal motor truck manufacturing companies, the Cartage Exchange of Chicago, and the Motor Truck Association of the State of Illinois was formed. Several meetings were held and considerable information collected. The investigation resulted in a recommendation that team-track driveway widths be determined on the basis of a truck eight feet wide and twenty-seven feet long.

The third phase of the study resulted in replies from questionnaires being received from twenty-seven railroads covering 117 different team tracks. This information is tabulated in Table 10 on page 429. The average width of team track driveways reported, built subsequent to 1920, or proposed, and on which there is no criticism as to traffic delays, is about thirty-eight feet.

The second phase of the report deals with freight-house driveways and a general treatment similar to the one just discussed for team tracks is followed.

On pages 432 and 433 appear the conclusions of the Committee. It is recommended that these be accepted and published in the Manual.

I have already called your attention to several of them. The first, second and third have been covered. I think the fourth, fifth and sixth should be mentioned.

4. Outside of heavy machinery, heavy rolls of paper, and similar shipments, practically all commodities handled on team tracks are adapted to side loading of trucks.

5. At present only about ten per cent of the trucks used in team-track service are adapted to side loading.

6. It is not advisable at the present time to recommend generally a width of team track based on exclusive side loading of trucks, though the economic advantages of this method of loading from the railroad's standpoint are obvious. Truck manufacturers should be encouraged in the building of trucks adapted to side loading.

Under Conclusion 7 we give the result of our recommendations as to team-track widths. Several conditions are covered.

8. The distance between track centers where the driveway is located between tracks should be ten feet greater than the width of the driveway.

The spacing of tracks, where multiple team tracks are built, may be fixed by regulatory bodies, but it is recommended that the minimum distance between track centers be 13 feet.

10. Stub-ended driveway serving team tracks should be avoided. Where team tracks are more than 20 cars long (per single track), intermediate connecting cross drives should be provided. In large team-track developments where exceptionally long tracks are provided, cross drives should be introduced so that 14 cars per track is the maximum length between any two drives.

No. 11 should have one word changed. Those of you who have read the report will notice that that conclusion does not compare with the body of the text. It should read the minimum width instead of the maximum width.

11. The minimum width of a freight-house driveway should be sufficient to provide for trucks backed up to the freight house at right angles and to leave room in front of the truck for two trucks to pass.

The last recommendation, No. 12, covers the width recommended for freight-house driveways.

I wish to discuss briefly Recommendation 10. That recommendation was discussed at length by the Committee. It is one that is not susceptible of definite calculation and is largely a matter of judgment. There are advantages and disadvantages in cross drives. It was felt, however, that we should set down something to indicate our best judgment, and that is what Recommendation 10 is intended to be. We cannot defend it on the basis of any definite calculation such as two plus two is four. To illustrate, if a team track were a mile long, our recommendation would favor splitting it up into nine separate sections for cross communication. Some might contend that the fourteen should be sixteen, ten or twenty. That number is not possible of definite calculation.

In behalf of this Committee I wish to move that the conclusions on page 432 and 433 be accepted as recommended practice and approved for publication in the Manual.

Mr. L. Brousseau (Canadian National) :—I want to discuss Conclusion 10. It seems to me that the recommendation is somewhat premature and

deserves further study before being incorporated as a conclusion. It is noted, on page 419, the fourth paragraph, that the Committee found difficulty in locating team tracks with sufficient density of traffic, resulting in a large amount of delay.

In another part of the report it is stated that the number of observations made was somewhat inadequate to make precise assumptions. In view of this would it not be better to give more study to this particular question of driveways so as to get more definite conclusions in next year's report?

When looking at Exhibit 1 on page 434, which is a questionnaire on driveways, the subject of cross drives is not even mentioned, and the Committee might judge perhaps that this question is of secondary importance, but to me it seems it deserves more consideration before final recommendation is made in our Proceedings.

The establishment of cross drives and their locations, to my mind, involves operating principles which are very important, such as delays in switching cars and the considerable amount of coupling and uncoupling, as well as the spotting of cars to give room for these cross driveways. Will these conditions not outweigh the slight reduction in delays to traffic on the driveways concerned? I would think, therefore, that the matter should be studied further for the benefit of the whole railway engineering profession, so as to give us the benefit of what you find by a questionnaire, for instance, getting views from more railroads on the subject.

Mr. C. H. Mottier:—The speaker has just raised some points that were discussed by the Committee. If I might take the time to read one paragraph in the report, I think that it will indicate the position of the Committee. I might say and I give this as my personal judgment and not as the opinion of the Committee, because I have never discussed this particular feature with them, that we could study the particular question raised by the previous speaker for a long period and would not know more about it at the end of the period than we know now. It is a question on which there is little possibility of arriving at an accurately determined and precise conclusion. It is largely a question of judgment. We have studied it very carefully and have talked to men who operate team tracks, both railroad employees and truck operators.

I will now read on page 420, beginning just before the table. I think you will get the point we are trying to make. "There is a greater tendency for delays to occur in stub-ended than in open-ended driveways. This is due to the fact that with driveways open-ended, a teamster need not be limited to one entrance but can drive around and enter the driveway from the end free from blockade. This fact should receive major consideration in the design of team-track facilities. Obviously the longer the open-ended driveway becomes, the more nearly it approaches, in effect, two stub-ended driveways joined at the stub ends. The shorter the driveway the less liability for delays. It is recommended, therefore, that wherever possible, stub-ended driveways be avoided. It is recognized that intermediate cross driveways are objectionable in that they require the cutting of cars and some decrease in capacity, but it is felt, nevertheless, that where team

tracks are more than 20 cars long (per single track) that intermediate cross drives should be introduced. In large team-track developments where exceptionally long tracks are provided, cross drives should be introduced, so that 14 cars per track is the maximum length between any two drives."

When this report was prepared by the Sub-Committee the 14 was 10 and the Committee of the whole raised it to 14. I would like to read one further comment on page 430. "One of the principal cartage companies of Chicago reported (I will leave out the part that is not pertinent) that they should have cross driveways connecting the several driveways at not more than 600 feet apart."

Our recommendation, based on 42 feet per car, amounts to 588 feet or, as I said before, to about one-ninth of a mile.

We found in our studies that many old team tracks with narrow driveways that were practically obsolete before, have been made serviceable by cutting them up into shorter lengths by adding cross driveways so that when a teamster comes in, if he finds he cannot get through on one driveway, he can go on to the next driveway and come back.

I think, Mr. Chairman, it is still the opinion of this Committee that the recommendation should stand.

The President:—Is there any further discussion? Are you ready for the question?

Those in favor of the motion will say "aye"; opposed "no." The motion is carried.

You may proceed, Mr. Chairman.

Mr. J. E. Armstrong:—Owing to the unexpected and unavoidable absence of the Chairman of the Scales Sub-Committee, the report on Scales will be presented by Mr. H. M. Roeser.

Mr. H. M. Roeser (U. S. Bureau of Standards):—The report of the Scales Sub-Committee of the Yards and Terminals Committee is found on page 435 to 438 of Bulletin 302. The assignments to the Sub-Committee for the current year were two in number, and consisted of specifications for various types of scales used in railway terminals, and a study and report upon the disposition of track scales which have been removed by reason of inadequacy, obsolescence or inaccuracy.

We did not have anything to do in connection with the first subject and consequently we have nothing to report.

The second subject was brought to our attention through a letter from Dr. Burgess, of the United States Bureau of Standards, to the Secretary of the American Railway Association under date of January 19, 1927. It appears, as I suppose most of you know, that there is a large percentage of the American public, some of whom ship and have business with railroads, who, whenever they find something going on that they do not like, sit down and write a letter to the Government asking them to do something about it. Of course, if you have read the letter in the Bulletin you will find that Dr. Burgess did about the only thing he could do, which was to sit down and write to somebody else. Of course, in time the letter drifted down to the Scales Sub-Committee.

In handling the matter we took as a major consideration the fact there is a great tendency by traffic departments to distribute the weighing of origin freight, that is, instead of concentrating freight at yards for weighing they are spreading it out. It is very important that the shipper himself have a scale which is identical with the one the railroads have.

It so happened, as Dr. Burgess pointed out, that carriers have discarded, for reason of inadequacy or obsolescence, through a scrap jobber various and numerous types of scales. Later they have found themselves accepting weights of carload freight over these same scales through a weight agreement which their traffic departments have made with the different shippers. This consideration and other minor ones led us to the conclusion that a track scale which has been removed by reason of inadequacy, obsolescence or inaccuracy should be disposed of in either of the following ways:

"Treat as scrap metal after rendering unfit for further use as a scale or parts thereof.

"Retain for use as repair parts of existing scales of the same type and size."

That is the conclusion of the report, Mr. Chairman, and I move its adoption.

The President:—It has been moved and seconded that the conclusions appearing at the bottom of page 438 be adopted for publication in the Manual. The question is open for discussion.

Mr. C. W. Baldridge (Santa Fe):—I think the Committee makes a mistake in including the word "inadequacy" in this first conclusion. It is possible for a thoroughly good, accurate scale to become inadequate as to size for general use in a railroad yard, and at the same time that scale might be abundantly large for the use of some industry whose output was of such nature that their carloads would always be light enough to be handled by that scale. If the scale has become unworkable or inaccurate, it is perfectly proper to demolish it, but simply because it is inadequate for the place where it is used, does not mean that it is inadequate for other points, and a scale that is adequate for use somewhere else and is in good condition should not be condemned as this conclusion proposes to do.

I would favor the adoption of the conclusion with the word "inadequacy" stricken out, and I believe that the Committee should consider striking out that one word and adopting the conclusions as applying to scales which are either worn out or inaccurate only.

Mr. H. M. Roeser:—I think, speaking for the Chairman of our Sub-Committee in general, and for myself in particular, it would not be wise to strike that word out for the reason that scales which become inadequate for railroad use, as a result of being too light in design and construction, are actually too light for use in practical weighing of freight anyway. I say that because light commodities to which the gentleman referred are generally and, in fact, practically altogether handled on a minimum weight basis, so they do not have to be weighed at all.

The other consideration is this: That any scale anywhere is likely to have to weigh the maximum loaded car. A shipper who weighs his com-

modity, however light, for originating freight purposes, sometime or other is going to weigh coal and other material coming into his plant for accounting purposes and for the purpose of filing claims against the carrier for short weighting. For that reason it is important indeed that every shipper who handles his freight on a weight agreement basis has exactly the same kind of a scale that the carrier would have if he was doing the weighing himself. That is the principle that led the Committee to the conclusion they have reached.

The President:—Is there any further discussion? Are you ready for the question?

(The motion was carried.)

The President:—Mr. Chairman, you may proceed.

Mr. J. E. Armstrong:—In connection with the assignment on Hump Yard Design, the Sub-Committee has carried out a considerable amount of preliminary investigation, but at the present time is not in a position to make any report. It simply reports progress.

Mr. President, this concludes the report of the Yards and Terminals Committee.

The President:—It is apparent that this Committee is working in anticipation of the time when the terminals in great cities will become more and more congested and the operation will have to be carried on more efficiently. This Committee has undertaken and has done major work for a number of years past and it is to be congratulated upon the excellent report presented to you this morning. The Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY OPERATION

(For Report, see pp. 438-474)

Mr. James M. Farrin (Illinois Central) :—The report of this Committee is to be found on page 439 of Bulletin 302. In addition to the report as shown in this Bulletin, the Committee during the past year has had occasion to review a criticism of a former report that was made by the Committee, I believe in 1925, having to do with the traffic capacity of a railroad. This former report was criticized very closely by Mr. Parodi, Consulting Engineer of the Paris-Orleans Railroad of France and a member of this Association. Mr. Parodi differed somewhat in his analysis of this question from that presented by the Committee in its former report, so the Committee took upon itself the task of reconciling Mr. Parodi's criticism with their former report. This was done by Mr. E. E. Kimball, of the Committee, all of which appears in Bulletin 299 of September, 1927.

I wish to digress just a little here and say that this Committee at any time would welcome a discussion of any of its recommendations and conclusions. In fact, we are glad to have them. We believe that a little competition in this respect will be good for us.

To go on with the report as found on page 439, our first report is No. 2 —Develop and report on methods for obtaining a more intensive use of existing railway facilities, with particular reference to increasing carrying capacity;

(a) Without material additional capital expenditures;

(b) With due regard to reasonable capital expenditures consistent with traffic requirements.

Mr. M. F. Mannion, the Chairman of this Sub-Committee, will present this report.

Mr. M. F. Mannion (Bessemer & Lake Erie) :—The report of Sub-Committee No. 2, marked Appendix A, is found on pages 441 to 451. This year the Committee felt that a report containing the operating statistics and physical characteristics of a heavy traffic single-track road or section of road showing what traffic can be handled on a single-track road would be very valuable. Also what improvements if any were made to increase this capacity and the effects of same.

The Committee selected the heaviest traffic section of a single-track railroad, upon which average steam railroad conditions exist, that they could find. The selection made was a 48-mile single-track section of one of the large Southern roads, on which an average of 28 passenger trains and 28 freight trains were operated per day (both directions) during 1926.

On pages 441 and 442 is shown the sketch map of the section of the road, also some of the physical characteristics of same. On page 443 is a profile of this section of the road and also a plan showing the automatic signals which were later installed. Page 444 shows the improvements which were made in order to increase the capacity of this single-track section between 1922 and 1926, also the description of the motive power.

At the bottom of page 444 and on pages 445 and 446 are given some of the operating statistics, which are: The average number of passenger trains daily; the average number of freight trains daily; the average number of cars per freight train; the gross tonnage handled by months; the average freight train speed miles per hour, and the average freight train running time.

In Fig. 3 these operating statistics were plotted. You will note from Fig. 3 that from 1922 to 1926, inclusive, there was an increase in the number of trains per day, the number of cars per train, the tonnage handled and that there was an increase in the running time from 1922 to 1924, inclusive. There was a decided decrease in the running time in 1925 and in 1926.

The Committee then plotted the average running time per train against the number of trains as shown in Fig. 4, 5, 6, 7 and 8 on page 447, and they also plotted the average running time per train against the gross tons per mile as shown in Fig. 10, 11, 12, 13 and 14.

In Fig. 15 they superimposed the roads' characteristics, which is the slanting line in the other figures, upon each other, and Fig. 15 shows the following: That there was an increase in capacity in 1925 and 1926 over 1922, and that there was an increase in 1926 over 1925.

In Fig. 14, for an average running time of 4 hours, there is shown an increase in capacity during 1925 over 1924 of 450,000 tons per month, or approximately 43 per cent. In 1926 there is shown an increase in capacity over that of 1925 of 525,000 tons, or approximately 35 per cent. The total increase in capacity in 1926 over 1922 is 975,000 tons, or 93 per cent.

Fig. 15 also shows that the time required to handle the 1922 tonnage during 1925 was reduced 39 minutes per train, while during 1926 it was reduced one hour per train over 1922. Also the time required to handle 1925 tonnage in 1926 was reduced 25 minutes.

As stated in the previous pages, aside from a change in motive power during these years, the only improvements made in facilities were the automatic signals, which were not put into operation until 1926, and increase in weight of rail.

Upon investigation the Committee learned that beginning with 1924 more study and supervision was given to the operation of trains over this section of road. Efforts were made to reduce delays and keep trains moving regularly and at a moderate and efficient speed. Every effort was made to reduce train stops. A reduction in 31 orders and an increase in 19 orders occurred. The results accomplished by this increase of supervision are shown by the performance of 1925.

All the improved operation and increased capacity obtained in 1926 can be laid to the installation of automatic signals, as there was no change in power used, sidings, grades, alinement, operators, or speed limit of trains in 1926 or 1925. However, there was a further reduction in 31 orders and an increase in 19 orders.

The principal reason for the saving in time with automatic signals was the reduction of the spacing between following trains. Before signals were installed the trains were operated by train orders and spaced station to

station or an average of five miles. With automatic signals in use a train can follow another as soon as train has traveled an average distance of 0.79 mile.

The conclusions of the Sub-Committee are shown on page 451:

1. Increased supervision, consisting of scientific study and thoughtful efforts, will increase the capacity of a railway.

2. Installation of automatic block signals on a single-track railway will increase the capacity of the road, this increase varying with the length of the division on which installed and with the number of passenger trains operated.

3. The above methods of increasing capacity being very economical ones, resulting in a saving in road time on present traffic and increased earnings as traffic increases.

4. In addition to the increase in capacity, supervision and automatic signals provide other intangible benefits. These were reported in our report contained in Bulletin 284.

5. A single-track railway, with proper supervision eliminating unnecessary delays and train stops, proper number and spacing of sidings, and proper signaling, is a very efficient transportation machine, all of which have more intensive use than a double-track line handling traffic which does not reach its capacity.

Before second track is constructed, careful study should be given to the practicability of increasing the capacity of the single track, either by increased supervision and study of operations, signals, or electrification, etc.

The Sub-Committee wishes to submit this report as information.

The President:—The report of this Sub-Committee is submitted as information, but it is apparent that the Committee is desirous of submitting this method of approach of a solution to the problem. This is a very important problem, and the Committee would welcome any suggestions from members on the floor as to the method of approach to a solution of it or any suggestions you may have to make. I will be glad to hear from any of you gentlemen.

Mr. J. P. Hanley (Illinois Central):—I understand that on many railroads the question of eliminating a certain number of water stations in connection with the more rapid operation of trains is being considered. The size of the engine tenders is becoming greater, and necessity for rapid train movement is increasing, as indicated by the report just submitted by Mr. Mannion.

I would like to suggest that the Committee give specific study to the proposition of recommending the spacing of water stations with the idea of improving the movement of trains in the same manner as they have treated block signals and the other devices included in their report.

The President:—Are there any further suggestions?

Mr. F. M. Patterson (Railway Age):—I should like to inquire as to the per cent of grades.

Mr. M. F. Mannion:—The maximum or ruling grade I think was one per cent.

Mr. F. M. Patterson:—I take it that remote control of switches was not used.

Mr. M. F. Mannion:—No.

Mr. F. M. Patterson:—Is not that one element that would improve or expedite operation?

Mr. M. F. Mannion:—The Committee had under consideration an installation of remote control switches which they had hoped to report on this year, but they have not been able to obtain the information to make a complete report on that as yet. They hope to do that sometime in the near future.

The President:—If there are no other suggestions, the Chairman may proceed with the presentation of the next subject.

Mr. James M. Farrin:—Subject No. 3, develop and report upon methods and formulas for solution of special problems relating to more economical and efficient operation, Appendix B. The work of this Sub-Committee during the past year consisted of editing and getting in shape for publication in the Manual the previous report. It has no new work to report this year.

Subject No. 4, begin study to determine the most economical make-up of track to carry various traffic densities. It happened that Subject No. 4 was in conflict with a subject that had also been given to the Rail Committee, so after taking this up with the Board of Direction it was determined not to attempt to make a report at the present time until the Rail Committee had gotten together its information and made its report.

Subject No. 5, develop suitable units for operating and equipment statistics required by the Interstate Commerce Commission to be used in cost comparison of transportation, equipment, and roadway maintenance with necessary additions thereto, collaborating with Committee XI—Records and Accounts, and Committee XXII—Economics of Railway Labor. It was our desire to make a complete report this year, but unfortunately due to illness in the family of the Chairman in charge of this Sub-Committee, it was not done. This year we hope to completely finish the subject and make a report at the next meeting.

Subject No. 6, determine what volume or other condition of business or service justifies a change from flat switching to the hump method in any given yard, collaborating with Committee XIV—Yards and Terminals. This report is given in Appendix E, and I will ask Mr. J. F. Pringle, the Chairman of the Sub-Committee, to submit his report.

Mr. J. F. Pringle (Canadian National):—The report of the Committee is found on page 453 of Bulletin 302. A questionnaire was sent out to about twenty railroads, of which fourteen replied. The report of the Committee this year consists of a summary of the replies received to that questionnaire. It is intended to study these replies further and collect further information this year to try to arrive at definite conclusions to be presented in next year's report. The report is submitted as information.

Mr. James M. Farrin:—Relative to this report which has just been given, I wish to state that this is a subject upon which the Association

at large should have a great deal of information. We would be very glad to have any information or criticism you can give us, as we realize that it is going to be a rather difficult thing to finish this report and get it in acceptable shape. This year we hope to devote our energies to finding out just exactly what it costs, or as near exactly as it can be determined, to put a car through a hump yard. In previous investigations that have been made we find there is very little real information on the subject.

The President:—Progress reports under Subjects 3, 4, 5 and 6 will be received as information, if there are no objections.

Mr. Chairman, you may proceed with the presentation of the report.

Mr. James M. Farrin:—Subject No 7, study problems of railway operation as affected by the introduction of motor trucks and bus lines, with particular reference to its effect upon branch or feeder lines. Mr. H. C. Crowell will give this report.

Mr. H. C. Crowell (Pennsylvania):—This is the second year that the Committee has been studying the motor coach and truck problem, a problem which is proving exceedingly difficult of solution. Last year, in addition to furnishing statistics that showed the encroachment of private and public automobile traffic on railroad passenger traffic and revenues, we made a study of what may be called the "branch line problem," including suggestions as to the procedure to be followed in making an unprofitable branch pay, and in abandoning it if it can not be made to pay.

This year we have brought our revenue passenger statistics up to date and have stated briefly the competitive highway situation as we see it at the present time. The statistics are presented on page 458 and analyzed on pages 457 and 459.

I should like to invite your attention to some of the more salient features of these statistics.

You will note that the number of passengers carried reached its maximum in 1920 and has steadily declined to a minimum for the eleven-year period ending in 1926. (At the time this report was made, figures for the year 1927 for Class I railroads in this country were not, of course, available.)

The number of passenger miles also reached its maximum in 1920 and has declined more or less continuously ever since. The figures for 1922 and 1926 were the lowest since 1916.

The length of the average journey has shown a fairly steady increase since 1916, indicating that the loss in passengers carried has been largely, if not entirely, in the short-haul riders.

I might say right here that this particular piece of information is subject to approximation for the reason that it is impossible to secure absolutely the number of passengers carried in this country. For example, if a passenger uses three railroads in making his trip, he becomes three passengers because he is a passenger on each of those three roads and he makes three journeys. This, of course, has a tendency to cut down the indicated length of the average journey, but for the purpose of comparison, I think the approximate figures are sufficiently good to indicate the trend.

Passenger revenue reached its maximum with the increase in fares in 1920, and in 1926 had declined to the lowest figures since 1918.

Also the revenue per passenger mile has declined since 1921.

As to the service that the railroads are rendering to the public, passenger train miles in 1926 reached its maximum since the slump following the war, the 1926 figure being the highest since 1917, when troops were being mobilized.

On the other hand, the passengers per train have been declining since the peak in 1919.

The passenger car miles reached a maximum for all time in 1926. This shows that the decline in passengers, passenger miles and passenger revenue was not brought about by the failure of the railroads to give adequate service.

As a result of these items immediately preceding, the passengers per car in 1926 reached the lowest figure for any year in the period covered and possibly the lowest in all history. This figure is approximately fourteen passengers per car, and let it be remembered that that includes all of the revenue passengers in suburban traffic, and I think it is not unusual on roads that carry heavy suburban traffic, like the Illinois Central and the Long Island Railroad, to find 100 or even more than 100 passengers in a car. Yet with all of these big figures added in, the average remains only fourteen passengers per car.

We were able to secure some figures for the first nine months of 1927. We found that the loss in passenger revenue when compared with the same months in the preceding year was even greater in 1926 than it was in 1925.

For the first time in many years the travel in parlor and sleeping cars has declined, previous losses having been confined to the coaches, where the length of journey is comparatively short. That item is very significant. It indicates, to my mind, that the motor coach rider is no longer solely a short rider, but he is becoming a long-haul rider. Journeys of 1200, 1500, or even 2000 miles by motor coach are now not unusual.

At the bottom of page 459 we give three reasons why we think the motor coach business is increasing.

On page 460 I should like to invite your attention particularly to two paragraphs. The middle paragraph on this page suggests that in determining substitutes for unprofitable steam train service, the maximum economy be obtained in one step. I think you will find that in many cases expensive rail motor cars have been purchased because they showed a saving when compared with the cost of existing train operation, and after running them a little while, managements have found out that still more saving could be obtained by substituting motor coaches on the highways. Of course it is evident that the thing to do is to make that economy in one step instead of taking two steps to accomplish the result.

Then again, in the paragraph at the bottom of page 460, we hold up a warning sign to the people who are prone to use accounting statistics without investigating what lies back of those accounting statistics. Not many of us like to delve into those figures. I assure you if you do not want to

fool yourself, you had better find out the make-up of the figures that are given you.

I say that with proper deference to the accounting people. For example, if your Controller informs you that a certain unprofitable passenger train operation is costing $1.50 per mile, find out whether that $1.50 includes interest on the full investment and depreciation by the straight-line formula, a duplication which we as Engineers know exists right at the start. But aside from that duplication, find out also if the small unprofitable steam passenger train is made up of a decrepit engine and one or two obsolete coaches, which if replaced by a $60,000 rail motor car could not possibly be put anywhere but the scrap heap. If so, the cost of operating the steam passenger train must include nothing more than the interest on the scrap value of the obsolete equipment, certainly nothing for depreciation because that, no doubt, has been, or should have been, accrued already.

This is particularly important in connection with trains making a small daily mileage, because this fixed overhead when divided by a small number of miles per day runs into a considerable figure, and it may be sufficient to indicate a saving by the substitution, when really there is no saving.

We state at the bottom of the page, "On lines where daily mileage is small these fixed overhead items represent a considerable portion of the total mileage cost and the theoretical savings may be only the result of inaccurately figured fixed charges. Regardless of the accountant's method of figuring costs for entirely different purposes, the analyst should confine himself to a practical, common-sense viewpoint."

In the next paragraph we mention the fact that recently there have been designed two or three steam-driven motor coaches. We have had steam-driven motor coaches in years gone by, we have had steam-driven rail motor cars, but adequate thought was not given to the design of those units a generation ago. I understand, though, that at the present time very much work and good work is being done in connection with the design of steam-driven motor coaches and steam-driven rail motor cars. It goes without saying that the use of steam for the propelling of these units, especially the rail motor car, will fit in best with the operating crew. In other words, the engineman will fit in better with the operation of a steam-driven rail motor car than he will fit in with the operation of a gas-mechanical or a gas-electric rail motor car. Railroad operating officers should follow carefully these new experiments in rail car design.

In addition we have this year presented two appendices, or exhibits, one of which is a copy of a paper submitted by Harold F. Fritch, Passenger Traffic Manager of the Boston & Maine Railroad, to the Transportation Meeting of the Society of Automotive Engineers held here in Chicago three months ago, entitled, "Rail Car or Motor Coach—The Economic Field of Each." There is much good material in Mr. Fritch's paper, and all of you who are interested particularly in this subject will read it to advantage.

Right here I wish to say that the railroad fraternity owes a debt of gratitude to the Society of Automotive Engineers for its hearty co-opera-

tion in this problem. The Society of Automotive Engineers invites all railroad officers interested in the subject to attend its annual transportation meeting and to participate in the discussion, and even to present papers, and, in fact, any railroad officer who can qualify is welcome to join the Society of Automotive Engineers. This spirit of co-operation is certainly commendable.

A second paper is that prepared by Mr. M. F. Steinberger, of this Committee, describing the motor coach operation of the Baltimore & Ohio Railroad in New York City, pictures of which we saw last night.

Since this report was prepared, the American Railway Association has formed the Motor Transport Division to study these matters. It will be impossible for us to do anything further, we think, without duplicating the efforts of the Motor Transport Division. Therefore, the Committee wishes to change the recommendation on page 462, and instead of suggesting that the subject be continued it wishes to recommend to the Board of Direction that in order to avoid needless duplication and in the interest of efficiency, the subject be discontinued.

The President:—This completes the report of the Committee on Economics of Railway Operation. Have you gentlemen anything to ask the members of the Committee or to suggest at this time?

Mr. H. M. Stout (Northern Pacific):—It seems to me that this Association would be a material loser if the Committee's recommendation were followed. I have in mind the impracticability of the Association following in an adequate manner the steps being taken in the evolution of passenger transportation without a report similar to the excellent one which Mr. Crowell, as Chairman of the Sub-Committee of this Committee, has presented today. I for one hope the recommendation will be ignored by the Board of Direction, to the extent that the recommendation be not followed

The President:—That matter will be referred to the Board of Direction for such action as may seem advisable to be taken.

The Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY LOCATION

(For Report, see pp. 475-490)

Mr. F. R. Layng (Bessemer & Lake Erie):—The report this year is simply one of progress. The matter in connection with Appendix A will be presented by Mr. F. L. Batchelder, the Chairman of that Sub-Committee.

Mr. F. L. Batchelder (Copper Range):—The subject assigned to Sub-Committee 2 is the Economics of Railway Location, as affected by the introduction of Electric Locomotives. The Committee was unable to put any great amount of work on the consideration of this subject this past season, but attempted to express in rather a short, precise manner the different things to be considered in the economic comparisons of electrification and grade revision. This is presented in Appendix A on page 476. As the Chairman has already stated, this is offered as information.

The President:—If there is no objection, the information will be so received. You may proceed, Mr. Chairman.

Mr. F. R. Layng:—On page 477 is Appendix B, the subject of which is Relative merits of increasing tonnage by the reduction of ruling grades, or by the introduction of more powerful locomotives, including consideration of momentum grades and the availability of the locomotive booster. I will ask Mr. W. L. R. Haines, of the Sub-Committee, to present this matter.

Mr. W. L. R. Haines (Pennsylvania):—Appendix B is practically a monograph prepared by Mr. C. P. Howard, of the Interstate Commerce Commission Engineering Department. The Committee found it a rather difficult matter to set down any rules and contented itself with a reiteration of principles which may seem to be elementary, and yet which many Engineers appear to overlook in handling problems of this nature.

I want to call attention to two typographical errors. On page 479, in the third paragraph, beginning "To effect a given reduction," etc., the last line reads, "except for the differentials paid enginemen according to the age of the locomotives." That should have been "size of the locomotives."

There is also another error in the third line of the fourth paragraph following. It speaks of "abandoning parts or perhaps all of the new line." It should have read "of the old line."

The Sub-Committee presents this as information only.

The President:—Are there any questions to be asked regarding this subject? If not, the report will be received as information.

Mr. F. R. Layng:—On page 480 will be found Appendix C, the title of the subject-matter being "Locomotive capacity, giving special attention to oil-burning locomotives, collaborating with the appropriate committee of Division V—Mechanical, A.R.A."

I will ask Mr. W. H. Winterrowd, Chairman of the Sub-Committee, to present this matter.

Mr. W. H. Winterrowd (Lima Locomotive Works):—The Sub-Committee in dealing with its subjects kept in mind the economics involved and

gave its first attention to information that would enable Engineers to calculate how locomotive capacity can be increased by means of the Locomotive Booster.

The Booster is probably known to most of you gentlemen. It consists of a pair of cylinders that generate power which is transmitted at will to trailer truck or tender truck wheels by means of gearing. It adds great tractive effort to the locomotive by utilizing the weight on trailer or tender trucks.

The application of this device to existing power as well as to future power is a simple matter of economics. This report is an endeavor to place before you some facts, data and methods which will enable you to calculate the advantages and economics of the Booster for any set of conditions involved. To the best of my knowledge this is the first general resumé of its nature that has been placed in the hands of Engineers interested in railway economics. The tables are simple and the charts easy to use, and it is hoped they may be of some service to you.

In a few words, this covers the presentation, which is offered as a matter of information.

The President:—You have heard the Chairman's report. Are there any questions to be asked or suggestions to be made? If there are none, the report will be received as information.

Mr. Layng, have you any further statement to make?

Mr. F. R. Layng:—During the coming year the Committee intends to take up actively the study of some of the lines that have been electrified. The Committee expects to make a personal visit on one of these lines in the South and hopes from that experience to be able to bring you something of interest next year.

We are also going to continue the study in connection with the light-grade lines. We have had some very interesting information from the Hocking Valley, especially in connection with their new line south of Columbus. We hope to get some very interesting information from the Illinois Central when they get their new three-tenths line into service.

Mr. Chairman, I believe that covers all the matters we have at this time.

The President:—Do any members of the Association have any suggestions to make regarding this Committee's work? If there are none, the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY LABOR

(For Report, see pp. 491-501)

(Past-President J. L. Campbell in the Chair.)

Mr. A. N. Reece (Kansas City Southern):—The Committee on Economics of Railway Labor has devoted its time during the past year to the study of four subjects. An attempt was made to close out only the first, or Appendix A, which is, "The extent to which it is practicable to stabilize employment in the Maintenance of Way Department in the interest of efficiency, and the measures necessary to accomplish it."

In the absence of the Sub-Committee Chairman, I will present the report on this assignment, which has been divided into three parts:

(1) The equalization of expenses.
(2) The determination of the extent to which the maintenance of uniform forces is justified.
(3) The effect of stabilization of employment on uniform purchases of materials and their costs.

Definite conclusions on each of these items were presented at the last convention, and were adopted for printing in the Manual. The purpose of continuing the study of this subject was merely to review and bring forth any added information that might be helpful in the practical application of the data collected.

The Sub-Committee's report, appearing on pages 492 to 495, inclusive, contains this additional information, which, we believe, is set forth in proper form to substantiate the conclusions heretofore adopted by the Association.

I move the Sub-Committee's report be accepted as final.

Past-President J. L. Campbell:—Any discussion?

(The question was put to a vote and carried.)

Mr. A. N. Reece:—Our second subject is "Economy in the use of labor-saving devices," Appendix B. This report will be rendered by Mr. G. M. O'Rourke, the Sub-Committee Chairman.

Mr. G. M. O'Rourke (Illinois Central):—Appendix B will be found on page 496. In 1926 the Committee reported on motor cars, weed destroyers, rail cutting and building-up devices, tie-tamping machines, rail-layers, ditchers and locomotives cranes. In 1927 attention was confined to devices used in distributing, cleaning, tamping and dressing ballast and to track liners. This year's report was to cover studies in rail-handling devices, rail-oiling devices, the advantages of using machines such as ditchers singly and in tandem, and the use of mechanical, air and electrically-driven tools.

A questionnaire was submitted to the railroads of this country and of Canada, but the returns were so few and the data so brief, with the exception of those from five roads, that your Committee can report progress only, and hopes for a more generous response from representative railroads during the coming year.

Past-President J. L. Campbell:—If there is no objection, this report will be received as information.

Past-President J. L. Campbell:—Mr. Ford, the Committee will depend upon you during the coming year for some information that will be of assistance to them.

Are there any other suggestions in connection with this report?

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—As a representative of a road that has made very extended use of a number of labor-saving devices, I think I can offer some explanation of why it is difficult to evaluate the savings brought about by these machines. The chief difficulty in the way is to avoid or be able to value the liability of the machine when it is lying idle. Many of these machines cannot be used all the time. Another difficulty in the way is that on some divisions the use of these machines is interfered with by traffic, whereas on others the traffic is light and great economies can be secured where there is demand for the machine.

I do not remember now just what reply our road made to the questionnaire if we made any, or whether we got a questionnaire, but if we did I believe I would have enlightened them on our part as far as I have now endeavored to do.

Mr. F. R. Layng (Bessemer & Lake Erie):—I fear the trend of this discussion might lead some to think that the railroads have been negligent in this matter. I think that would be an unfortunate impression to allow to stand. The facts are, we have made remarkable progress and it only remains for us to report to this Committee what we are doing and what we intend to do in order to get into our Proceedings the good work that has been accomplished.

Mr. G. M. O'Rourke:—We received five replies, and from what those five contained we might have made a brief progress report.

We did get a reply from Mr. McDonald. We got a reply from the Rock Island Lines, but I can not say that they gave us all the information we asked for. Perhaps we asked for too much. One railroad, and one only, covered every question we asked fully, and gave us a very comprehensive reply to the questionnaire.

Past-President J. L. Campbell:—Are there any further suggestions?

Mr. C. W. Baldridge (Santa Fe):—I was just noticing there are nine names on this Sub-Committee. They sent out a questionnaire and got five replies. If they had sent the questionnaire to the members of the Committee they should have gotten nine.

Mr. C. E. Johnston (Kansas City Southern):—Perhaps the reason they did not get replies in certain cases was that they could not prove any economy in these so-called labor-saving devices. I think many times a good way to increase costs is to add machinery. I know of one roundhouse where the cost of turning locomotives is the lowest on the system and they have nothing but a grindstone. As soon as you have machine tools you add to the cost of turning locomotives. I merely mention this phase of the question.

Mr. W. H. Kirkbride (Southern Pacific):—Just at this minute I do not know whether that portion of my road that I represent made a reply, but I think it is pertinent in answering the questionnaires that we should

have the facts as to whether they point to the fact that a machine is an economy or otherwise.

I wish to call attention to the fact that a good many of the machines are in the experimental stage. Therefore, in answering the questionnaire a person must be very careful and conservative in arriving at conclusions.

This leads me to a general observation. I do not apply it to this particular Committee, but I think there could be a decided improvement made in the manner of sending out questionnaires, and to whom the questionnaires are sent. I think many of these questionnaires go astray because they are not sent to an official that is interested, particularly in the A.R.E.A. work. It might be well to improve our methods in seeing that the questionnaires are sent to the members of the A.R.E.A., who certainly should have enough interest in their Association to see that answers are made.

Mr. W. C. Barrett (Lehigh Valley) :—I am not certain whether our road is one of those which answered the questionnaire or not, but I think we have used labor-saving devices on our railroad longer than any other railroad, and I can say emphatically that they have been economical. One of the reasons why we have been able to keep our cost of maintenance per track mile down where it belongs is that we have done everything we possibly could with labor-saving devices.

We use locomotive cranes for nearly everything. One speaker, I notice, mentioned the fact that some of the machines would lie idle. By using a locomotive crane for laying rails and almost everything else, we keep it busy all the time. The fact is, we have to schedule each crane in order to have a crane available for rail laying when required. There is no lost motion on our railroad in the use of labor-saving devices.

Mr. W. P. Wiltsee (Norfolk & Western) :—I should like to suggest to the Committee that they consider labor-saving devices that will operate off the track. That is getting to be a very important feature in connection with labor-saving devices. Some roads with heavy traffic are getting too many machines on the road and cannot operate them long enough to make them economical.

Past-President J. L. Campbell :—If there is no further discussion, this progress report will be received as information. You may proceed, Mr. Chairman.

Mr. A. N. Reece :—The third assignment is Standardization of Motor Car Parts, Appendix C; Mr. J. A. Heaman, the Sub-Committee Chairman, will report on this subject.

Mr. J. A. Heaman (Grand Trunk Western) :—The report of this Committee is on page 497, Appendix C. Your Sub-Committee on Standardization of Parts and Accessories of Railway Maintenance Motor Cars has during the year been unsuccessful in making arrangements for joint work with the manufacturers or their committee. On the other hand, the manufacturers have expressed their willingness to work with your Sub-Committee and have advised they were considering the question of standardization among themselves and would report on the results of their deliberations.

This report has been received, but too late for consideration before the present convention.

Past-President J. L. Campbell:—Are there any suggestions in connection with this progress report? If not, it will be received as information.

Mr. A. N. Reece:—The fourth assignment is Equating Track Values for Labor Distribution, Appendix D. I will ask Mr. J. M. Sills, of the Committee, to report on that subject, it being also a progress report.

Mr. J. M. Sills (St. Louis-San Francisco):—In further studying the equating of track values for labor distribution the Committee sent out a questionnaire to determine the necessity of equating additional track features to those shown in the report of 1922. Results are set forth in the report which you, no doubt, have already read.

The Committee, therefore, believes that, at this time, there is no necessity for adding to the old values.

There is one point which I would like to stress in connection with this report. The method shown is not a definite mathematical way of distributing money but simply an aid to so-called judgment which, possibly, in many cases, is based on guesswork. It is thought that the railroads can better the manner of distributing money by introducing some formula such as we have tried to develop.

Past-President J. L. Campbell:—Are there any suggestions in connection with this report?

Mr. H. C. Crowell (Pennsylvania):—There is so much of value in this report that I hesitate to appear to be picking flaws in it, but there are two or three things I would like to mention if the Committee would care to hear them at this time.

At the bottom of page 499 it appears that on this particular western road about 40 per cent of the labor expenditures for maintenance of the track did not vary with the traffic, and that same 40 per cent has been used in working out a problem on an entirely different railroad in a different locality. No doubt that 40 per cent is perfectly proper for the particular road that is referred to at the bottom of page 499, but if we are going to deal in averages I suggest we get back to a formula of Committee XXI—Economics of Railway Operation, in which it was demonstrated with reasonable accuracy that on the average about two-thirds of all Maintenance of Way expenditures do not vary with the traffic.

At the top of page 500, and, in fact, throughout that page, if I understand the formula correctly, there are many changes that should be made to make it complete and accurate. In these first two tabulations, of course, it is not 0.40 per cent but it is 40 per cent, 3 per cent, 1 per cent, 82 per cent, etc.

Furthermore, in the fourth line, instead of reading "per million gross tons of freight per mile of track," I take it that should read "per million gross ton miles of freight per mile of main track per annum," which is quite a different thing. I think, though, the Committee probably had that in mind, but did not put it down in so many words.

On the next line also "per 5000 cars of passenger equipment" I think should read "per 5000 car miles of passenger equipment per mile of main track per annum." Cars and car-miles and tons and ton-miles are two dif-

ferent things, as you will find out if you go to the operating statistics of the Interstate Commerce Commission.

In the twelfth line "freight traffic, 10,000,000 tons at 0.3 per million"; it should be 3 per cent per million, or 30 per cent. That is merely, I take it, a typographical error.

In the next line 5,000,000 is stated instead of 5000.

Then in the tabulation in the middle of the page the column headings should be changed considerably. For example, instead of passenger cars per mile of main track, that should become "passenger car-miles." I think it can be demonstrated if you use cars instead of car-miles, you will not get the right answer.

Then so far as the checking is concerned, this reminds me of the story of the engineering party that came back after leveling for nine miles and reported they had checked within 2/100 of a foot. This particular formula works out so well that it might almost be distrusted. It shows that 1766 men were required for the territory as a whole, when there were actually 1,769; almost too good!

I would suggest that the Committee during the coming year apply this formula to one road, say the New Haven or the Richmond, Fredericksburg & Potomac, that has heavy passenger traffic, and then likewise to another road with heavy freight traffic, such as the Chesapeake & Ohio or the Virginian, and see how well it will work out.

With those minor corrections, I think the formula is a good one and the report excellent.

Past-President J. L. Campbell:—Are there any other suggestions?

Mr. Hunter McDonald:—At the bottom of page 499, refer to the table of the kind of work not affected by traffic. We have just been discussing the question of use of labor-saving devices. Grassing track is very decidedly affected by traffic where it is done by weed-killing machines, also the mowing of right-of-way where it is done by track mowers.

Past-President J. L. Campbell:—Are there any other suggestions? If not, the progress report is accepted as information.

Mr. A. N. Reece:—Mr. Chairman, that completes the report of the Committee.

Past-President J. L. Campbell:—This completing the report of the Committee, it is now relieved with the thanks of the Association. (Applause.)

DISCUSSION ON TRACK

(For Report, see pp. 593-604)

(Past-President J. L. Campbell in the Chair:)

Mr. J. V. Neubert (New York Central):—Mr. Chairman, the report of the Track Committee is in Bulletin 303, page 593. In Appendix A, Revision of Manual, it is recommended that all future plans and specifications of the Track Committee have initials "A.R.E.A." (standing for American Railway Engineering Association) placed thereon in a conspicuous manner, preferably above the main title. Existing plans and specifications are to be modified in this respect only when reprinted. I so move, Mr. Chairman.

On the plans that the Track Committee made heretofore, there is no identity, whether they are A.R.E.A. or some other railroad standards. The Committee felt there should be some indication to that effect.

Past-President J. L. Campbell:—Unless there is objection, it will be so received.

Mr. J. V. Neubert:—It is proposed to withdraw Plan No. 953, Details of Movable Point Crossings, angles 8 deg. 10 min. to 15 deg. 30 min., inclusive, dated November, 1926, adopted March, 1927, and substitute plan of the same number (953), entitled, "A.R.E.A. Details of Movable Points for Curved Crossings, angles 8 deg. 10 min. to 15 deg. 30 min." dated revised November, 1927.

The proposed plan practically consists of the same plan, except that we close in the movable point closer, which is much better on the wider angles and will take care of the possibility of the movable point on curves. I so move, Mr. Chairman.

Mr. S. E. Shoup (Kansas City Southern):—In connection with this plan 953 submitted by the Committee this year, if I understand the plan correctly the title is somewhat misleading, because this title reads, "Movable Points for Curved Crossings," and the note directly under the graph reads "Drawn for No. 6 angle on tangent track, but either or both tracks may be curved." It would seem to me that this whole plan is as applicable to straight crossings as it is to curved crossings. Further, the clip detail on this plan is designated to be used in interlocking plants. I for one would like to know whether that is recommended by the Committee to be used where crossings are hand-thrown.

Mr. J. V. Neubert:—It is the intent that this plan is to be used for tangent as well as curved tracks and also is to be used at hand as well as interlocking stations.

With regard to the title, we possibly could change that. What have you to suggest?

Mr. S. E. Shoup:—I suggest it be made "Movable Points for Tangent or Curved Crossings." That would meet both conditions.

Mr. J. V. Neubert:—Would you object to cutting out the word "curved"?

Mr. S. E. Shoup:—Not particularly.

Mr. J. V. Neubert:—Within that angle you would only use the movable point curved. I think the plan is all right. I was wrong in my statement.

Mr. C. E. Johnston (Kansas City Southern):—We are quite interested in the simplicity and clearness of our plans in the Manual. May I suggest that perhaps it would be well to have the Committee undertake to clarify it, so that we may all know what it means?

Mr. J. V. Neubert:—The limits are shown by the diagram at the top of the plan, where you use your difference between your rigid crossings and your movable point shown in the graphic diagram.

Past-President J. L. Campbell:—Is there any further discussion upon this motion?

Mr. D. A. Kuebler (Kansas City Southern):—In the lower left corner of the diagram with reference to planing the point, it indicates that the top of point rail is to be planed level with top of stock rail unless reinforcing rail is omitted or unless otherwise specified, in which latter case top planing for the ramp will extend two feet only from end of point, the end of point to be brought level with top of stock rail in either case as shown.

I am wondering if that could not be clarified in the diagram or further explained. It may be perfectly clear to the manufacturers, but it seems that it might be further clarified.

Mr. J. V. Neubert:—Will Mr. Strong please explain that?

Mr. J. B. Strong (Ramapo-Ajax Corporation):—I will read the note in question, amplifying as I go along.

"Top of point rail to be planed level with top of stock rail."

This means when the point rail is made reinforced as shown there will be no ramp or elevation on the point rail. As an alternate the note goes on to say: "Unless reinforcing rail is omitted or unless otherwise specified, in which latter case top planing for the ramp will extend only two feet from the end of point." That means the full elevation or ramp when specified will be reached two feet from the end of the point rail.

"The end of point to be brought level with top of stock rail in either case as shown." That is, the top of point rail will be level with the top of stock rail or knuckle rail where the gage line spread is 1¼ in., as indicated on the plan. I believe this is perfectly clear to the manufacturers and if carefully read should not be interpreted otherwise than as explained.

Mr. A. F. Blaess (Illinois Central):—I think that title is somewhat misleading. Anyone looking at it would believe this diagram is intended merely for movable points for curved crossings. While it says from 8 deg. to 15 deg. in 10 min., there is nothing to indicate it except the diagram for rigid crossings. It seems to me that ought to be as clear as it can be before it is published in the Manual.

Mr. J. V. Neubert:—Mr. Blaess, I thought perhaps the diagram would cover that limit. It comes in the limit of the movable point crossings in the graphic diagram in the center, the same graphic diagram that was on last year and previous years.

Past-President J. L. Campbell:—Any further discussion on the motion? The motion is on the substitution of the first three paragraphs of the Com-

mittee's recommendation appearing on page 595 of Bulletin 303, ending with the word "end," for the matter now in the Manual. Are you ready for the question?

(The question was called for, put to a vote and carried.)

Mr. J. V. Neubert:—Withdrawal of Plan 983, Solid manganese steel frogs for 7-inch and 9-inch girder rails. The Committee felt that this plan needed a little more detail as well as it needed the table showing the length of arms of frog Nos. 4 to 10, inclusive. I recommend that revised Plan 983 be adopted.

Past-President J. L. Campbell:—It is moved and seconded that Plan 983 be adopted as revised.

Mr. S. E. Shoup:—On Plan 983 may I ask why No. 7 and No. 9 were not included? Is it the standard practice of this Committee to leave out the No. 7 to 9 frogs in these plans?

Mr. J. V. Neubert:—When you get into girder rail construction, it is what may be called more or less special construction. These angles shown are the ones most generally used. The Committee as yet has not made up plans for the intermediate angles shown on this table up above.

Mr. S. E. Shoup:—Do these plans apply only on the grooved girder rail or also apply to the high T-rails?

Mr. J. V. Neubert:—Grooved girder, 7 to 9 inch.

Mr. S. E. Shoup:—It seems to me it would be better for the grooved girder rail.

Mr. J. V. Neubert:—This Association adopted a 7-inch and a 9-inch girder rail the same as they have adopted the T-rail.

Mr. S. E. Shoup:—Is this the standard A.R.E.A. 7 to 9-inch girder rail with the groove in it?

Mr. J. V. Neubert:—We have a groove in it.

Mr. S. E. Shoup:—Then I am at fault. I did not know that we had that.

Past-President J. L. Campbell:—Any further discussion? If not, all in favor of the motion to adopt revised Plan 983 will say "aye"; contrary "no." The motion is carried.

Mr. J. V. Neubert:—The corrections which are shown on Plans 305 and 308, 771-B, 773, 640, 643 and 670, 651, 652, 653, 654, 655 and 656 and 774 are merely some slight changes of plans which were adopted prior to other plans which have more improved conditions and these slight changes are recommended for correction of the plans referred to, to bring them up to date.

I so move you, Mr. Chairman:

Past-President J. L. Campbell:—Is there any discussion on this motion? If not, all in favor of the motion will say "aye"; contrary "no." The motion is carried.

Mr. J. V. Neubert:—Under the specifications for switches, frogs, crossings and guard rails, it is proposed that Section 33 read as follows, on gages and flangeways:

"Track gage may be $\frac{1}{8}$ inch under or $\frac{1}{16}$ inch over that specified for manganese construction and $\frac{1}{16}$ inch under or over for bolted construction.

"Guard gage (distance between guards) shall not exceed that specified but may be 1/8 inch less.

"The width of flangeways may not be less than specified nor more than 1/16 inch wider than specified.

"All the above measured on the level of gage line 5/8 inch below tread surface.

"Flangeways shall not be less than 1 7/8 inch deep measured from top of tread surfaces, unless otherwise specified."

I so move you that this be incorporated in the Manual.

Past-President J. L. Campbell:—Is there any discussion on this motion? If there is no discussion, all in favor of substituting these revised specifications for the matter now in the Manual, will say "aye"; contrary "no." The motion is carried.

Mr. J. V. Neubert:—The Committee and the manufacturers, as well as several railroads, have found that the paragraph under the specification of Section 47 should be more or less enlightened, and it is proposed to revise this Section 47 as follows:

"The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery.

"No guarantee of specific length of service will be required. A claim for defective material and/or workmanship shall cover only such defects as will impair the life of the work.

"No claim for free replacement of defective material and/or workmanship shall be recognized unless made promptly and based on defects appearing within three months from date of installation and in any event within two years from date of shipment."

I so move you, Mr. Chairman.

Past-President J. L. Campbell:—Is there any discussion on this motion? If not, all in favor of this Revision of the Manual as covered by this motion say "aye"; contrary "no." The motion is carried.

Mr. J. V. Neubert:—It is proposed to revise the index sheets, of which there are now three in the portfolio of Track Work Plans, into four, and we have substituted these index sheets to bring them up to date.

I so move you that these corrected index sheets be adopted for inclusion in the Manual.

Past-President J. L. Campbell:—All in favor of the adoption of these indexes for inclusion in the Manual will say "aye"; contrary "no." The motion is carried.

Mr. J. V. Neubert:—The report of Appendix B is on page 597, Report on matter now appearing in the Manual relating to curve elevation, canvassing various railroads with a view of ascertaining their practices and views, and recommend such changes as are found desirable. The Committee has only a progress report to make. We revised the questionnaire sent out in previous years, because we felt that the questionnaire sent out in 1926 was more or less misleading. Mr. Breed and his Sub-Committee have issued a questionnaire, and it was through very hard work on their part that 100 per cent answered that questionnaire, but the majority of those answers

were received only quite recently. It is the intention of the Sub-Committee to visit several of the railroads where there is more or less dispute in regard to the subject.

Several members who have had controversy in regard to the superelevation of curves have asked us to give an opinion. If the Sub-Committee writes to your road for information, we will be glad if you will give us some food for thought, because I imagine when this subject is presented, which will be next March, without doubt there is going to be quite a controversy on it. We will be very glad to be enlightened in any way. There will be a number of railroads, as I said, on which we are going to investigate conditions, where there seems to be a wide diversity of certain practices.

As stated, this is a progress report.

Past-President J. L. Campbell:—The Committee would like any suggestions.

Mr. B. R. Leffler:—Is it in order to make a few remarks regarding curve elevation right now?

Past-President J. L. Campbell:—It is.

Mr. B. R. Leffler:—The table of curve elevations as given in the Manual is based on certain assumptions as to speed of the equipment operating over the curve. There are certain well known principles of mechanics which are applied in using this assumption. The further assumption is also made that the object or equipment moving on the curve is composed of a rigid, solid body, just like a block of wood; knowing the speed of this object, and knowing the curvature, superelevation naturally follows by certain principles of mechanics.

The assumption of a solid body moving in a curve has been used throughout the whole history of railroad engineering. I wish to say that my study leads me to believe it is fundamentally wrong, for this reason: the object that moves over the curve is not a solid body, it is composed of two solid bodies connected by an elastic medium, this elastic medium being the springs carrying the load.

In the former days of railroading when the equipment was rather small in capacity, this assumption of two solid bodies connected by an elastic medium was not of much importance as compared with present-day equipment. In other words, the assumption led to no serious error in determining the superelevation of curves.

I dare say if the Committee would make a study of this idea of two solid bodies connected by an elastic medium, they will reach some surprising results, in particular on sharp curves, with a superelevation corresponding to the elevation given in the Manual. I think that is a point that the Committee wants to carefully consider in revising the Manual; in other words, the possibility of too much elevation.

The Committee should also make a study of the effect of lateral forces on track caused by swaying equipment. In this study they will find some of the nicest principles of theoretical mechanics involved. For instance, a locomotive sways, or a car sways, the center of gravity moves to the right

and left. It is a well-known principle in mechanics that you can not move the center of gravity of a body without exerting a force whose direction lies in the direction of the motion of the center of gravity. That means that all swaying equipment exerts a lateral force on track. I reached the conclusion that a 70-ton hopper car swaying may exert a force of 9000 lb. laterally on the track. It does not make any difference whether it is a curve or tangent. The force is a reversing one like the swaying itself. A rapidly reversing force is usually a difficult one to take care of.

The principles underlying superelevation of track can all be expressed in terms of mechanics and formulated in a definite mathematical way. It is an interesting and practical study.

My study leads me to conclude that most curves, sharp curves in particular, are elevated too much for the equipment as ordinarily operated over it. It is well to remember that, in these high center of gravity loads, only about 8 per cent of the total load is an unsprung weight, composed of the trucks and the brake rods and other parts not supported by the springs; whereas in a locomotive which has usually been used as the body to determine the superelevation, the unsprung weight, which operates like ballast in a ship, amounts to 19 per cent, which makes a great difference in the stability of a locomotive going around a curve as compared with the stability of an oil tank car or a high center of gravity coal car or any car with high loads, such as stills, high transformers, etc.

I think all of these points should be considered by the Committee in revising and considering the question of the proper superelevation of the outer rail. It may be that it is advisable to resort to rail wear; let the rail wear, and remove the outer rail rather than attempt to elevate too much and reduce the wear. In fact, if you elevate too much you get the wear on the lower rail anyhow, depending on the amount of slow-moving equipment going over the track as compared with the amount of fast moving equipment.

Past-President J. L. Campbell:—Perhaps Professor Talbot has something of interest to say on this subject.

Dr. A. N. Talbot (University of Illinois):—I think of nothing that would be helpful at this time. I am much interested in the remarks made by Mr. Leffler. It seems to me the questions raised should be taken into account in any study of the subject.

Mr. Louis Yager (Northern Pacific):—Mr. Chairman, this question of superelevation is very important. There have been some serious derailments in recent years, the explanation of which have been very baffling. I am very much impressed with the suggestions that have been made by Mr. Leffler as having an important bearing on this subject. I believe the Committee should take them into consideration, and, if they desire or deem it necessary, the Committee on Outline of Work will so change the scope of the question as to include re-investigation of the theoretical mechanics upon which the matter now in the Manual is based.

Past-President J. L. Campbell:—Is there any further discussion of this motion?

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I believe this matter has been studied by the Committee. I had hoped we

would reach a satisfactory conclusion of the matter certainly at the end of two years, but I am very much encouraged to find that we are likely to reach it at the end of another year.

My experience in studying derailments has led me to believe that the very much larger number of derailments occur from having too much superelevation rather than too little. I personally do not know of any derailment that ever occurred, although I have seen some reported in the Interstate Commerce Commission reports, wherein I was satisfied that the derailment was due to lack of superelevation. I believe derailments arising from lack of sufficient superelevation would exhibit an overturning of the train, that is turning over from the outside rail and not the phenomenon of flanges mounting the rail.

Mr. W. H. Kirkbride (Southern Pacific) :—You can make your mathematical calculations as to how much you should elevate a curve, but you must then consider from a practical point of view that you are dealing possibly with combined traffic on a single-track railroad, namely, passenger and freight, each unit operating at different speeds. You therefore must strike a compromise and make your curves safe for the passenger movement and likewise safe for the operation of freight trains around the curves.

It is a well-known fact that if you put too much elevation in the curve, a box-car is going to derail. It is my thought that in approaching this problem, the Committee can well consider the safety of applying the principle of the center third, that is keeping the resultant of forces within the center third of the track, and it is my further thought that in enunciating any rule for elevation, we should establish tables dealing with the maximum speeds on curves for different superelevation of outer rail. In other words, given a certain territory which you have under consideration and recognizing the traffic which you have, set up your rule so that the Operating Department will be confined to maximum speeds around the curves that you have elevated on a predetermined basis.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe) :—Mr. McDonald made the statement that he did not recall ever knowing of a derailment on the outer side of the curve on account of speed, I believe.

Mr. Hunter McDonald :—On account of lack of superelevation.

Mr. C. W. Baldridge :—I have had the opportunity to follow up two derailments which it was practically certain were due to speed in excess of that provided for by the superelevation. The first of those occurred during wartime with a light engine on the Santa Fe road going west, upgrade, where all trains ordinarily are able to run not to exceed 25 or 30 miles per hour, curves were elevated accordingly.

This light engine was making excessive speed. It was estimated as going about 70 miles an hour. It reached the end of a 10-degree curve elevated for 25 or 30 miles an hour and left the track without turning over sidewise. It never did turn over sidewise, although it went off on a fill of at least 20 feet high. The engine pitched forward, nosed into the ground, and turned over endwise, flat on its back.

A few years later we had a doubleheaded passenger train which owing to some taunting of one engineer by another, as near as we could afterward learn, was run at excessive speed and struck an 8-degree curve. The entire train was derailed. Both engines were derailed. Those engines did not turn over until they had gone a considerable distance from the point of derailment, reaching a fill which would have rolled them over had they been set down carefully.

Those engines left the track going straight ahead as they struck the curve, and it was unquestionably due to speed considerably greater than the curve was elevated for.

Mr. W. H. Courtenay (Louisville & Nashville):—We have reason to believe that two engines were overturned bodily on the outside of the curve by excessive speed. All indications led to that. One of them was a light section of a fast passenger train on a 10-degree curve. The other was a light regular train on a 12-degree curve. There were cuts in both cases and the engine turned over against the cut.

Mr. Hunter McDonald:—I do not think the two cases cited at all prove the rule. One of them shows that the engine derailed on tangent after having traversed the curve. That was very possibly due to the excessive high speed setting up lateral vibration and causing the flanges of the wheels to knock the track out of line. I do not care to prolong this investigation. All I am after is to try to get the table that is now set up in the Manual, which I think is misleading, withdrawn from it and something more logical substituted.

Mr. B. R. Leffler:—I would like to ask Mr. Baldridge whether those tracks were properly tapered.

Mr. C. W. Baldridge:—They were. It is our uniform practice to use easement curves and in both cases these derailments were at the beginning of the curve. The engines did not take the curves, they went straight ahead.

Past-President J. L. Campbell:—If there is no further discussion, this will be received as information.

Mr. J. V. Neubert:—The Committee would be very glad to get any criticism or suggestions from any of the members, particularly those who spoke, as well as others. Some of the answers in the questionnaire, if I remember correctly, indicate that there is no limit of speed on any curve.

Detailed plans for switches, frogs, crossings and double slip switches, including self-guarded frogs, were handled by Mr. Harding.

Mr. C. R. Harding (Southern Pacific):—The report of the Sub-Committee is found on page 598. The Sub-Committee recommends for adoption and printing in the Manual, five plans. I move the adoption of Plan No. 775, dated revised November, 1927, solid manganese crossings, steam railroad over steam railroad.

Past-President J. L. Campbell:—If there is no objection to this motion, these plans will be adopted.

Mr. S. E. Shoup:—On plan 775, again the title reads, "Solid Manganese Steel Crossings." It would seem that that title should read, "Solid Manganese Steel Crossing Frogs with Interior Connecting Rails," because

it does not seem to me that the crossing outlined in this plan is a solid manganese crossing. The frogs themselves are solid manganese, and I suggest that modification be made.

Mr. C. R. Harding:—If there is no objection, the wording of the title will read "Solid Manganese Steel Frogs." Of course this is one of a series of plans of crossings. I doubt whether there should be any confusion from the title the way it now reads.

Mr. S. E. Shoup:—Furthermore, it would seem to me that the plans should specify that the rails between the crossing frogs themselves should be furnished by the manufacturer. I do not think that note is covered in the plan.

Mr. J. V. Neubert:—We have a detailed plan that was adopted about two years ago showing how to order crossing frogs.

Past-President J. L. Campbell:—The motion before the house is on the adoption of Plan No. 775 as it stands on page 599. Unless there is a motion to amend this motion, the question will be upon the original motion.

Mr. C. E. Johnston:—I should like to make that motion.

(The motion was seconded and carried.)

Past-President J. L. Campbell:—The original motion is amended to the effect that the title of this plan shall be "Solid Manganese Steel Crossing Frogs." Is there any discussion upon the amendment? The Committee accepts that change and the question is on the original motion. All in favor of the original motion will says "aye"; contrary, "no." The motion is carried.

Mr. C. R. Harding:—I move the adoption and printing in the Manual of Plan No. 955, dated November, 1927, details of solid manganese knuckle rail for No. 8 and No. 10 slip switches.

Past-President J. L. Campbell:—Is there any discussion?

(The motion was seconded and carried.)

Mr. C. R. Harding:—I move the adoption of Plan No. 600, dated November, 1927, rules for laying out rail-bound manganese frogs.

(The motion was seconded and carried.)

Mr. C. R. Harding:—I move the adoption of Plan No. 609, dated November, 1927, No. 9, 12 and 14 rail-bound manganese frogs.

(The motion was seconded and carried.)

Mr. C. R. Harding:—I move the adoption and printing in the Manual of Plan No. 610, dated November, 1927, No. 15 and 18 rail-bound manganese frogs.

(The motion was seconded and carried.)

Mr. C. R. Harding:—I recommend that Plan No. 343, dated November, 1927, No. 8, a selfguarded rigid bolted frog, be received as information.

Past-President J. L. Campbell:—Unless there is objection it will be so received.

Mr. D. A. Kuebler:—I would like to inquire if guard rails on that frog are so designed as to be reversible, that is, whether they may be reversed to increase the service life.

Mr. C. R. Harding:—No; they cannot be reversed.

Mr. D. A. Kuebler:—My idea is that some frogs are so designed, and I am wondering whether it would be desirable or not to have these designed accordingly.

Mr. C. R. Harding:—The Committee considered that point in its meetings and came to the conclusion that it was not desirable to have the design reversible. The information the Committee has is that those who built frogs with the idea of their being reversible found that they were unable to use them in that way and they actually did not reverse them.

Mr. J. V. Neubert:—Appendix D, page 600, Mr. Caruthers, Chairman.

Mr. E. W. Caruthers (Pennsylvania):—The report of the Committee is to be found on page 600. The plans have been prepared in accordance with the report, and are shown in detail. In connection with Plan No. 984, I move that this plan, dated November, 1927, No. 4 and No. 5 iron-bound manganese steel center frogs for 7-inch and 9-inch girder rails, be adopted.

(The motion was seconded and carried.)

Mr. E. W. Caruthers:—I move that Plan No. 985, dated November, 1927, No. 6 and 8 iron-bound manganese steel center frogs for 7-inch and 9-inch girder rails be adopted.

Past-President J. L. Campbell:—Unless there is some discussion, all in favor of this motion will say "aye"; opposed "no."

(The motion was carried.)

Mr. E. W. Caruthers:—I further move that Plan No. 986, dated November, 1927, No. 10 iron-bound manganese steel center frogs for 7-inch and 9-inch girder rails be adopted.

(The motion was seconded and carried.)

Mr. J. V. Neubert:—At the top of page 601 is Appendix E, design and specifications for foundations under railway crossings; also proper methods for spacing and timbering under railway crossings. Mr. O. F. Harting is Chairman of the Sub-Committee.

Mr. O. F. Harting (Terminal Railroad Association of St. Louis):—Report of this Sub-Committee is found on page 601 of Bulletin 303, and the four plans mentioned in the report immediately precede page 601.

I wish to direct your attention to the design of a reinforced concrete foundation for railroad crossings shown on Plan No. 721, and wish to explain that no attempt was made by the Committee to ascertain the thickness of the slab by calculation, as the problem involved is of an indeterminate nature. After the thickness of 15 inches was decided upon the amount of reinforcing steel was determined by the common formula to develop the strength of the concrete. The compressive strength of the concrete was taken at 700 lb. per square inch and the tensile strength of the reinforcing steel at 16,000 lb. This, therefore, represents more or less an empirical design based on the designs now in use by a number of railroads, and the Committee feels that this foundation will give entire satisfaction.

The Committee recommends that Plan No. 721, dated November, 1927, and presented last year as information, be adopted as recommended practice and printed in the Manual. Mr. Chairman, I so move.

Past-President J. L. Campbell:—Is there any discussion on this motion?

Mr. S. E. Shoup:—I should like to know how the Committee justifies the arrangement of the slab as shown in the upper righthand column of Plan No. 721. It seems to me those slabs are put in there backwards.

Mr. O. F. Harting:—Put in backwards? I do not understand your question.

Mr. S. E. Shoup:—I should like to know the explanation of the arrangement for the slab given in the upper righthand corner of Plan No. 721. That is, for angles between 40 and 60 degrees.

Mr. O. F. Harting:—There is no explanation; the sketch speaks for itself. That is the way that we recommend that the slabs be arranged.

Mr. S. E. Shoup:—It looks to me that there is a lot of waste material in the concrete.

Mr. O. F. Harting:—There is some waste in concrete when you use the precast slab. If you prefer to use the poured method of placing the foundation you will save concrete, but, on the other hand, having these slabs made of one standard size for all angles from 40 degrees to 90 degrees brings about a considerable saving, and that is what the Committee had in mind in recommending this one size slab; the slabs could, if so desired, be kept on hand in a storage yard. Does that answer your question?

Mr. S. E. Shoup:—Not entirely. I understand that, but it would seem to me that if the one on the extreme right were lowered a little bit and the one on the extreme left were raised, as is the one on the extreme right, it would be a very much better design.

Mr. O. F. Harting:—The idea in our arrangement is to have both wheels of an axle reach the edge of the concrete foundation at approximately the same time.

Mr. S. E. Shoup:—That does not work out on this sketch here because there is about two feet difference in the place that wheels hit the slab.

Mr. O. F. Harting:—If we move them as suggested by you it will aggravate that very condition.

Mr. S. E. Shoup:—It does not seem that it would aggravate it much when you get so much more utility out of your concrete.

Mr. J. V. Neubert:—I think the note in the lefthand corner may be some guide to you. I do not know how it is in certain localities, but where you have frogs insulated in the arms, you have to have the arms a little longer. If you feel you have a short frog and want to shorten up on the slab, shorten up on it. If you want to lengthen it, draw it out a little. It is the most advisable shape in regard to fitting in those angles. We tried one slab under the entire crossing which had to be made special to suit the individual angle for that crossing. Then we tried the four slabs for which the expense was much greater, but we found the two slabs of the shape that is shown here and that seems to be the most economical slab to fit under the angles as specified by this plan.

All you have to do if you want to see how that will plot up is draw up some kind of a scale in your office and take the block and slide it around

and see what different angles will suit, and if it comes in the dimension of angles shown in this plan.

Mr. S. E. Shoup:—I would certainly reverse the arrangement as you have it shown on this sketch here.

Another point about this: it would seem to me that the pile foundation crossing would either have been of sufficient consequence to have an individual plan, or it would be of insufficient consequence to have even a note such as this. I suggest that note be stricken out entirely. If the Committee wants to draw out a plan for pile foundation, all well and good, but I do not think we should dispose of it with any such note.

Mr. C. E. Johnston:—I think the whole plan should be remanded.

Past-President J. L. Campbell:—Do you make that as an amendment to the motion?

Mr. C. E. Johnston:—Yes, sir.

Mr. J. V. Neubert:—Just what is wrong with the plan? I believe there are hundreds that will be suited by these angles. The plan has been before the Association I think about two years.

Mr. W. H. Kirkbride:—I cannot see anything basically wrong with this plan. It seems to me the note in the lower lefthand corner answers the criticism. It reads: "Instead of making the concrete foundation of standard 6-foot and 12-foot precast slabs, special slabs may be used that more nearly fit the angle to the crossing." Surely that gives you leeway to work out your own individual problem.

Referring to the diagram in the upper righthand corner under the note, it says for all crossing angles from 40 to 60 degrees, use three slabs. That further gives you the leeway to work out your problem. Obviously you cannot outline every angle of a crossing on a standard drawing of this kind.

I furthermore see no objection to the information in connection with pile foundations. It certainly outlines two very proper methods of supporting crossings on piling. Why should we not have the benefit of this information on this drawing?

Past-President J. L. Campbell:—Any further discussion on the amendment? If not, all in favor of the amendment to refer this plan back to the Committee will say "aye."

(The motion was lost.)

Past-President J. L. Campbell:—The motion is lost and the question is now on the original motion. Unless there is further discussion, all in favor of the original motion say "aye"; contrary "no."

(The motion was carried.)

Mr. O. F. Harting:—We further present Plans Nos. 719-A, 719-B and 719-C, showing a diagonal method of arranging ties under railroad crossings having angles ranging from 8 degrees 10 minutes to 50 degrees. In these plans you will please note that the cross-ties are placed at right angles to the tracks, a very short distance from the ends of the crossings, eliminating the necessity of any slewing or skewing of cross-ties. The Committee has under consideration plans for tie layouts for crossings with angles 50 degrees to 90 degrees for presentation at a later date. The three plans

mentioned are offered as information to invite criticism, and I move their acceptance for that purpose.

Past-President J. L. Campbell:—If there is no objection, they will be so received.

Mr. J. V. Neubert:—Appendix F on page 602, study and report on methods of reducing rail wear on curves, with particular reference to oiling the rail or wheel flanges, collaborating with Committee IV.

Mr. C. M. McVay (New York Central):—This is a subject assigned with this year's work and the Committee presents the report that you find on page 602 merely as a progress report and as information. The Committee sent out a questionnaire about three months ago to all the roads that we were able to find who had tried the practice of oiling, or were beginning to try it. The question was left open in this questionnaire and a report was asked on it in April. The Committee felt that probably some additional information could be gotten about this practice if it was left over the winter, and the Committee wants to ask all the members of the Association who received that questionnaire and who have it, to please remember that we want an answer in April, and that we want all the information you can give us on it.

Another question was brought in. The Committee will try to report on devices other than oiling to prevent curve wear on the rail. One particular guard rail, for instance, has been brought to the Committee's attention, and if any of you have any such devices, we would surely be interested in hearing from you on them. Next year I think we can give you a much more detailed report on this subject.

Past-President J. L. Campbell:—If there is no objection, this report will be received as information.

Mr. J. V. Neubert:—Appendix G, on page 603, make critical review of material in former Proceedings with respect to the cause and effect of brine drippings, collaborating with Committee IV—Rail, and Committee XV—Iron and Steel Structures. Colonel Arn is Chairman of the Committee.

(President Brumley resumed the Chair.)

Mr. W. G. Arn (Illinois Central):—A review of the material in former Proceedings yielded only the following of special interest:

"The efforts of this Association finally resulted a few years ago in the adoption into the American Railway Association Code of Rules (M. C. B.) the following:

"Rule 3 (2) Refrigerator cars equipped with brine tanks. Suitable device for retaining the brine between icing stations. From owners.

"Information recently obtained shows the following: Most of the roads enforce interchange requirements in Rule 3 quoted above as to meat refrigerator cars, this rule having been put into effect January 1, 1923. For the United States as a whole, the rule is enforced about 95 per cent. This rule applies only to refrigerator cars constructed for meat shipments and equipped with brine tanks, and does not apply to the type of refrigerator cars in which fruits and vegetables are shipped.

"Beginning in 1923, salt is used to a limited extent in refrigerator cars other than meat cars.

"The practice of using salt in refrigerator cars other than meat cars is increasing, it being used in the shipment of certain berries, other fruits, melons, vegetables, fish, poultry and dairy products.

"It is anticipated that the use of salt in cars other than meat cars will continue to increase, and as a consequence brine drippings will continue to damage rail, track fastenings, bridges and interfere with signals unless protection is provided.

"Information obtained from various railroads indicates that no one protective coating, which is entirely satisfactory, has been found. Among the coatings which have been used more or less successfully are the following:

Crude oil
Asphalt and asphalt compounds
Tar and tar compounds
Mastic paint.

"A possible solution of this problem is the use of some refrigerant other than ice, preferably one which has no deleterious effect on refrigerator cars, track structures and the products which are being shipped. One such possible refrigerant is solid carbon dioxide (so-called 'dry ice'). The cost of this material is as yet so high that its use as a substitute for ice and salt or ice alone may not be justified, but the satisfactory results obtained from its use and the increasing extent of its use promise increased manufacturing facilities with a possible decrease in cost, which makes it a promising possibility for refrigerator car shipments.

"Conclusions. The Committee recommends that this report be received as information only and the subject be continued with the scope broadened to include investigation of promising substitute refrigerants."

Since the above was submitted to the printer, two articles of interest have been printed, one describing an iceless refrigerator car using silica gel, which appears on pages 406-7-8 of the *Railway Age* for February 18, 1928, and the other entitled "The Field of Dry Ice in Modern Refrigeration," which appeared in the February issue of *Refrigerating Engineering.*

While both silica gel and dry ice hold some promise as a future solution of the problem, there are serious difficulties in the way of using either of these articles. For instance, in the cars where silica gel is used, the apparatus is rather delicate and complicated for use in railroad transportation. In the case of solid carbon dioxide, a method of thermostatic control has not yet been devised. In either case, the extra expense and complications which would result from the use of refrigerator cars using two types of refrigeration would probably meet serious objection.

This is merely submitted as information. If any of the railroads have found a particularly effective protection, we would be glad to hear from them. The ones that were reported on, while more or less satisfactory, have in no case been entirely satisfactory.

Mr. W. H. Courtenay (Louisville & Nashville):—I would like to suggest a different recommendation from that recommended by the Committee, as all of you gentlemen know that matter has been under consideration for many years and nothing has been accomplished.

That immense damage to bridge structures and track materials is done by brine drippings from refrigerator cars is well established, but the money equivalent of such damage would be difficult indeed to ascertain.

The logical way to stop this destruction is to stop the cause, that is, to so modify the cars which carry brine as to enable them to retain it until it may be emptied at certain designated places, such as at icing stations or in division terminal yards, or at other convenient places where the effect of the brine may be localized or special provision made for receiving it.

All efforts to protect bridge steel from corrosion by brine by the application of paints of various kinds, or special so-called anti-rust coatings of various kinds, appear to have been futile, and it would be impracticable to attempt to apply any coatings of any kind to the heads of all the spikes, to the tie plates, splices, bolts, rails and other steel in the track structure even if an effective coating material were developed.

This matter has been before the railroads for many years, but notwithstanding the American Railway Association's interchange rule of 1920, which reads: "After October 1, 1920, no car carrying products which require for their refrigeration the use of salt with ice and which are equipped with brine tanks, will be accepted in interchange unless provided with suitable device for retaining the brine between icing stations," the evil continues; not only that, but it is growing worse.

Again Rule 3-f of the Interchange Rules, effective January 1, 1925, is as follows: "No refrigerator car equipped with brine tanks will be accepted from owner unless provided with suitable device for retaining the brine between icing stations." But so far as this speaker is informed, scant attention is paid to it.

Many refrigerator cars are the property of others than the railroad companies, and the handling of them is in many, if not most cases, competitive, consequently if one carrier declines to accept refrigerator cars not equipped in accordance with the Interchange Rules, another carrier will, and as traffic officers object to losing the business they are averse to declining to accept refrigerators which have no brine retainers.

Salt has been placed in the ice of refrigerator cars in recent years, which carry fruits and vegetables, without any provision whatever for retaining brine, which greatly increases the disastrous results.

Apparently the best method to endeavor to stop this very serious damage to property would be to prevail upon all of the railroads of the country to decline to accept cars with salted ice which are not equipped with efficient brine retainers from which the brine may be emptied at designated points.

There does not appear to be any serious difficulty about designing brine retainers by which this may be accomplished, and this may best be done by this Association presenting to the Mechanical Division of the American Railway Association the very great importance of the matter, with request that the Mechanical Division prepare a standard brine retainer, and then

urgently request that all carriers decline to accept refrigerators not so equipped.

The earnest co-operation of the American Railway Association should be enlisted, and I, therefore, make a motion that this important matter be referred to the Board of Direction of this Association for its careful consideration and appropriate action.

I notice this very capable Committee that we have just heard makes the following statement: "Most of the roads enforce requirements in Rule 3 quoted above as to meat refrigerator cars, this rule having been put into effect January 1, 1923."

That is not the experience of the Louisville and Nashville Railroad Company. That Company carries a great deal of fresh meat from East St. Louis through Evansville to Nashville and points southeast. The damage done by these brine drippings is tremendous.

I am informed that salt is not only put in refrigerator cars loaded with fresh meat which were not designed for meat carrying, but salt is put in increasing quantity in cars which carry fruits and vegetables. We have not a great many bridges between East St. Louis and Evansville, but those that we have have been badly damaged. It has been necessary to replace a great many of the lateral angles in the floor, and it has been necessary to replace the flange angles.

The bridge over the Ohio River between Evansville and Henderson has suffered a great deal of damage. The flat lateral plates, to which the laterals between the track stringers connecting them with the deck trusses are attached, have had all the heads of the rivets eaten off, to various extents, some of them so that there is practically no head left. The brine dropping from the refrigerator cars has pitted the truss members of the bridge below the deck, and this pitting has generally been done on the upstream truss, for the prevailing winds are in that direction.

During the past year we have had to cut apart and replace between trains the top plates and flanges, lateral braces, and tops of columns on the viaduct approach to that bridge on the Kentucky side.

We have endeavored to protect these with every kind of preservative we knew of. We have a bridge over Picon Creek in Evansville, a double-track bridge in the yards. It was thought at one time by soaking burlap in paint and applying it and painting it again we would get some protection. We did not get it. We have tried various anti-rust compounds, and other things which have been highly recommended to prevent rust, but none of them has succeeded. While the damage has been done to a much greater extent between East St. Louis and Nashville than elsewhere on the Louisville & Nashville Lines, it has been done to a great extent elsewhere.

On the St. Louis Division, a majority of the tie plates have been badly damaged by brine. A number of the tie plates, at least some of them sent to my office, have been entirely rusted away on the outside of the rail. A great many of the heads of the spikes are so far gone that the spikes cannot be pulled with clawbars. Other spikes have their throats so badly cut that they are useless.

This trouble not only occurs on that division but it occurs on other divisions elsewhere. Recently on a bridge on the division which extends from Louisville southeastwardly towards Knoxville, I noticed there were a double set of spikes on the track on the bridge. One set had heads entirely gone. The others were driven lately and were not yet gone. That is a place where there is a water station at the station next south of that bridge and the laterals of that bridge were all badly corroded to such an extent it had to be replaced.

Gentlemen, this matter, as you all know, has been before this Association for years, and while the interchange rules have been passed, we are not getting results. I think the matter should be taken up urgently and one of the difficulties so far as our own line is concerned, when I endeavored to get our people to absolutely refuse to accept these cars, they said, "Well, the other people will take them." The traffic men were present in the conference and they said they could not afford to lose the business. It may be true. If the traffic men do not want to lose the business and acceptance of it will ruin the railroad or greatly damage it, I think somebody should get busy and try to get all railroads collectively to try to follow these rules.

So far as I can find out, the Committee may be correct that 95 per cent of the roads are following these rules, but I wrote to Chief Engineers of about 25 or 26 railroads and they all wrote back to me that they were suffering too. I would like to know the roads that are not suffering, if there are any. I am much obliged to you.

The President:—Is there a second to Mr. Courtenay's motion?

Mr. Hunter McDonald:—Is there a motion before the house?

The President:—Mr. Courtenay made a motion.

Mr. Hunter McDonald:—I will second the motion so that I may proceed with the discussion.

I want to endorse all that Mr. Courtenay has said. The experiences on the main line of our road have been practically the same as he has outlined. We have endeavored to meet the problem, having considered it one which we could not have removed, by housing all of our steel bridges which are below the rail. We put raising pieces on the top of plate girders and chords, picking the track high enough to enable us to apply a galvanized iron covering which sheds the water off the girder or chord. Laterals are also covered with galvanized iron.

In regard to track fixtures, tie plates and rails, we spray our track with crude oil containing a high percentage of asphalt. We have been pursuing that plan for three years and I believe we are getting fairly tangible results.

Mr. W. H. Courtenay:—I would like to say we have tried the use of oil liberally during the past many months. We follow the practice on all of our girders and where we have steel track stringers hitched into floor beams, of covering the top of the floor-beams and track stringers with creosoted timbers, called raising pieces, about 4 inches thick, and we have them wider than the steel members they cover. They give considerable protection but I notice very recently on one of our bridges in the South that the

brine has been following under them by capillary attraction and attacking the steel. If any of you gentlemen want to find out what is happening, I suggest you shift the cross-ties. You will find the rust far worse under the ties than anywhere else, that is, on deck girders and track stringers.

Mr. W. G. Arn:—As further information, I might state that the railroads were not canvassed to see how many of them enforced this rule, but I consulted the various departments on our own railroad, and they referred me to the Federal Ice Refrigerating Company as one of the largest re-icing outfits, and they said to the best of their information the rule was enforced about 95 per cent, that there was some laxity in enforcing it.

The Committee considered, of course, the question of remodeling the cars which handle the fruit and vegetables to see if the brine tank could be put on that car the same as the other. The Mechanical Department and the Refrigerator Department both advised that that would be almost impracticable, it would be very troublesome and expensive.

One of the railroads objected to the use of salt in these cars and took the matter to the Interstate Commerce Commission. The Commission ruled that they must transport the cars with the salt on the ice even though they were not equipped with the brine tanks, and, without stating so, left the intimation that if necessary the railroad companies could apply for an increase in rates enough to take care of any damage that might occur.

Mr. Hunter McDonald:—Mr. Courtenay's difficulty about the protection of girders arises from the fact that he does not put a roof over the girder in the shape of a galvanized iron cover. This roof can be replenished and renewed by jacking the deck up whenever the brine drippings corrode sufficiently to require it. This plan, however, is not successfully applicable to open deck bridges.

If he will just put the galvanized iron cover on top of the raising piece, I think he will accomplish very good results. I know that we have done so and have been doing it for ten or twelve years.

Mr. W. H. Courtenay:—We have done that too.

Mr. B. R. Leffler:—I think that term 95 per cent is too rosy, too cheerful. I think we should consider the effect as appears on track construction. The 5 per cent that is left may do enough damage.

I have in mind a certain location where there is a drawbridge, with a long approach span, over one of the mid-western rivers where all the meat trains stop to take on water. It is a continual fight with brine. I do not care about this 95 per cent. It may look good.

There is another matter that we should have no delusions about, and that is as to protective coatings. I have made repeated tests by taking small pieces of metal, coating the metal with various compounds, including common red lead paint and linseed oil, and dipped them into the salt solution taken out of the refrigerator cars. The pieces were kept in the solution twenty-four hours, then exposed to the weather twenty-four hours, and so on for six months or a year, and not one of these so-called compounds amounted to anything. The best that showed up was the ordinary common red lead and linseed oil paint.

The trouble with a test like that, of course, is that it does not simulate actual practice. The only compound I have found which would hold up against actual service conditions was hot asphalt applied very carefully with the outside temperature just right, and all conditions just right, such as are very seldom found in actual application of painting.

Under those conditions, the hot asphalt applied will hold up probably three or four years, providing there is no mechanical abrasion.

The solution to this difficulty is to get rid of the brine. The Bridge Engineers are attempting to take care of it in their way by making the bridge sections of considerable excess area. For instance, the plate girder flanges and floor system can be made 15 or 20 per cent heavier. That is about the way it works out best from a practical standpoint.

Mr. Robert H. Ford (Rock Island) :—It may be of interest to the convention at this time to know that in assigning this subject, the Board of Direction had in mind for the Committee to make a critical review of material previously collected regarding the cause and effect of brine drippings. The subject is not new and a good deal of work has been heretofore done but conditions change and the discussions should be of assistance to the Committee in an effort to reach the cause in such a way as to permit constructive steps to be taken to remove or correct the situation.

The President:—Are you ready for the question?

Mr. G. H. Tinker (Nickel Plate) :—I think I can verify Mr. Courtenay's experience that the greater amount of rust occurs under the ties and not between. Capillary action carries the brine between the tie and the steel. The same thing will occur in the case of any kind of wooden protection. Wherever the brine can reach the underside of the wood, it is going to work its way between the wood and the steel and produce damage which is greater, because it is not seen, and because it is retained there a greater length of time.

I think that the remedy proposed by Mr. Courtenay will be futile. That has already been done. The Committee has reported the result, and members of the Association have reported their experience on it, that nothing has been accomplished, or very little.

I have no statistics, but I have examined a good many refrigerator cars, many of them which were iced by this same company which makes the report of 95 per cent. I never saw a car which retains brine. I think the only solution to the problem is to so design and build your bridges that the brine will not reach the steel; that is to say, make your bridges with a solid deck. It is not sufficient to put a roof over the flange of the girders because brine will be carried by the wind and strike the structure below. We have a great many high viaducts, and an examination of the bottom struts, at the bottom of the bents, shows they are pitted by brine; so unless the brine is kept from blowing about, striking the structure at other parts than immediately below the track, the damage will not be avoided.

Mr. W. H. Courtenay:—I want to be understood in this matter. I have some doubts whether even those deck girder bridges, which have concrete

floors re-enforced, fully protect against brine, but what I am trying to do in my effort is to get this Association, with all the influence and power which it can command, to endeavor to get all the railroads in the United States, which can be done through the American Railway Association, to abate this nuisance and stop this damage. It is a serious thing when the bridges cross large rivers and are attacked, damaged to such an extent that you must make renewal. They are costly; they are enormously costly.

The President:—Are you ready for the question? All in favor will say "aye"; opposed "no." The motion is carried.

Mr. Chairman, have you anything further?

Mr. P. T. Robinson (Southern Pacific):—It is assumed that the conclusions of the Sub-Committee just reached were based on the outlets of the brine from the present position, which in most cases, under my observation, is over the journal and directly over the track. If that is a fact, I think I have a partial solution of your trouble so far as the rail itself is concerned.

In Arizona the temperature of rail gets as high as 150 degrees. We found there was some enormous destructive force working on the ends of our untreated ties, to such an extent they were becoming badly broomed, the spikes would not hold, and that the life of the ties shortened up to as much as three and four years.

We began to look around to see what was causing this, and we found that when a long refrigerator train passed by, there was a constant dripping on the ends of the tie. We concluded that if we could remove that dripping from the point that it was being dropped, we might overcome the difficulties. We took it up with the refrigeration company, the Pacific Fruit Express, and asked if they would not change their outlets so they would come to the extreme outside of the car. They saw the point, and now as the cars go through the shops, they are changing them so the outlet is at the outside of the car.

So far as the improvement on the end of the ties is concerned, we changed the type of tie to a creosote and oil tie, so I can't say whether it is accomplishing anything in that respect, but the oil holds the particles of the wood fiber together, and does not permit the expansion and contraction that occurred before.

The President:—Mr. Chairman, have you anything further to report?

Mr. J. V. Neubert:—No, sir.

The President:—If there is nothing further, this Committee is excused with the thanks of the Association for the excellent work that has been done. (Applause.)

DISCUSSION ON RAIL

(For Report, see pp. 557-592)

Mr. Earl Stimson (Baltimore & Ohio) :—One of the most troublesome features of rail service is the tendency of the rail at the ends towards battering. This subject has been given very careful and exhaustive consideration by the Sub-Committee to which it was assigned and from time to time in the past few years reports have been presented. This year a report which is more or less in the nature of a final report is before you.

This Committee has done wonderful work under the very able leadership of Mr. McDonald. Mr. McDonald will favor us with the presentation of the report.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis) :—This is a progress report, but by courtesy of the Committee it is presented with some elaboration in order, if possible, to bring out discussion on conclusions which are pending for consideration at an early meeting to be called of the Sub-Committees of the Rail and Track Committees.

On page 580 of Bulletin 303, Part I, there appears a letter from Mr. W. C. Cushing, Engineer of Standards, Pennsylvania Railroad, in which he sets forth the possibilities of heat treatment of steel rail as a means of preventing rail battering.

On this same page, the closing clause of Appendix C to the Rail Committee's report for 1926 is reproduced and reference made to a paper by Mr. J. L. Fergus, Division Engineer, Nashville, Chattanooga & St. Louis Railway, in which he points out the effect of the variation in quality of steel rail to resist battering and the large savings to be expected by procurement of more uniform resistance to rail battering.

This subject is also referred to on page 584, where it is recommended that tests outlined in Appendix C be made by the Joint Committee of experts representing the Manufacturers' Technical Committee and the A.R.E.A. Rail Committee, which is studying the matter of improvement in quality of steel rail to cover both conditions of manufacture and service in track. Recommendations that such tests be made by this Committee have been made to the Board of Direction by the Rail and Track Committees.

There is also on page 584 brief reference to observations being conducted on the tracks of the Nashville, Chattanooga & St. Louis Railway and exhibits relating thereto, reference to which appears on pages 582, 590 and 591.

On pages 586 and 587 will be found the report on rail battering of the rail laid with head free and head contact joints on the Reading Railroad. This report was made by Messrs. Wrenshall, of the Reading, and Markley, of the Rail Joint Company, from batter measurements made by them at the request of the two Sub-Committees.

Attention is called to an omission of several pages from Exhibit O due to an error of the printer. These pages contained data from which Exhibit P was prepared. The error will be corrected in the Proceedings.

On page 581 will be found tentative conclusions formulated at the joint meeting of the two Sub-Committees, held on the Reading Railroad, which are to be presented for final consideration at a joint meeting of these Sub-Committees to be called at an early date. These are briefly as follows:

Paragraph 1: That a properly constructed taper gage is sufficiently accurate or adaptable to both statistical as well as service measurement of rail battering.

We have already put into the Manual a provision that a micrometer was best adapted to batter measurements for statistical purposes, but this conclusion seeks to withdraw that item from the Manual.

(a) That sufficient attention has not, in the past years, been bestowed on the care of rail during and after laying.

(b) That chipping may be reduced by readjustment of improper expansion spaces.

(c) That rail ends should be built up by welding when the batter equals $\frac{3}{64}$ of an inch, if such rails are to be retained in the track.

(d) That it is not economical to build up rail ends out of face.

(e) That investigation should be made to determine the best method of removing metal projecting into the joint gap as a result of welding or end overflow.

(f) That rail battering on high-speed tracks with traffic generally in one direction only may extend on the receiving end far beyond the joint gap, and, therefore, present methods of measuring may not be applicable in such cases. Such special cases should also receive special consideration with regard to the economy of welding as against resawing.

(g) That general milling of rail ends, as a means of reducing chipping is not justified.

On page 582 reference is made to the value of further investigations into the matter of lubrication to promote movement of rail through joints. This should include the possibilities and advantages of spraying the ends of rails with molten zinc, which will also promote electrical conductivity through the joint.

I want to add there that Mr. Backes has the question of spraying the ends with molten zinc under consideration for his line, and he advises me that he will shortly undertake that work with the experimental observation necessary to accompany it, and produce results.

I also want to refer to the possibilities of the development of a wrench that will successfully measure the human effort that is placed on the nut in tightening the bolt.

A gentleman on the Santa Fe, I believe, brought to my attention by Mr. Strachan, has this matter in hand, and I understand that the apparatus has almost reached a point of perfection.

The introduction of this type of tool will possibly enable the determination of a proper tension in bolts, and when we learn from the Committee on Stresses in Track just what tension we ought to have to produce the necessary strength in the joint, we will have made a very forward step in this investigation.

The President:—You have heard the report of the Sub-Committee on Cause and Prevention of Rail Battering. This is a very important subject, gentlemen. I am quite sure that the Committee will be glad to have your discussion of the question.

If there are no questions to be asked or suggestions made, the Chairman will proceed with the presentation of the balance of the report.

Mr. Earl Stimson:—One of the established features of the Rail Committee report is rail failure statistics. These statistics are compiled in the office of the Engineer of Tests of the Rail Committee. I will ask Mr. Barnes, the Engineer of Tests, to present this subject.

Mr. W. C. Barnes (Engineer of Tests, Rail Committee):—The rail failure statistics this year were received quite a little earlier than usual from the reporting roads, which has permitted us to issue these statistics at an earlier date, as well as to include in them a greater tonnage than heretofore reported.

You will note on page 562 of Bulletin 303 that we are now reporting on approximately 7 million tons, equivalent to 44,750 track miles of rail.

The statistics for this year have been prepared in the standard manner. They compare table by table with the last year's report. The outstanding feature of this year's presentation is shown in Table 1 on page 563. You will note that the righthand column shows that the average failures per 100 track miles for five years' service have been consistently decreasing since the 1917 rolling. The 1921 rolling, the last to complete its five years' service period, shows the low rate of failure of 98.9.

No doubt considerable credit for this is due to improvement in the mill output we have been receiving of late.

These results are shown graphically in Fig. 1, which shows a resumption of the downward trend of the rail failures since the high peak following the war.

If you will look at the four-year column in Table 1, you will note that the indications are the five-year record of 1922 rail will not quite equal that of the 1921 rail, but will still be better than the preceding four years. The following tables segregate the results by mills and repeat the same information for earlier rollings from previous reports.

The next of particular interest is the mill rating table in Fig. 3. Comparing Fig. 3 with Fig. 3 of last year, one will note that there have been slight changes in the ranking position of the mills as regards rate of failures, but if you pass on to Fig. 4, which presents the same data only after the introduction of a traffic density factor, you will find that the ranking is practically the same as last year, from which I would deduce that the distribution of the tonnages from the various mills has been somewhat different during this period, which is probably the cause for the change in the ranking shown in Fig. 3.

The average rail weight reported on has now reached 102.8 lb. per yard. This report is submitted as information.

The President:—You have heard this report, gentlemen. Have you any questions to ask, or any suggestions to make to the Committee? If there are none, Mr. Chairman, you may proceed.

Mr. Earl Stimson:—For many years your Committee has had under consideration the subject of mill practice as affecting the quality of steel rails. As the members of the Committee represent the users of the rails rather than the manufacturers, they have been in very much better position to note the effects rather than the causes, and while very exhaustive reports have been submitted from time to time on this subject, they have been more matters of information as to the various methods in the mills rather than any attempt to analyze the methods and determine remedial measures.

The subject has rested dormant for several years. It was prodded into life again this year by the Sub-Committee to which the subject was assigned, under the very able leadership of Mr. C. B. Bronson, of the New York Central Lines. The information has been brought up to date, outlining improvements in the manufacture of rails that have been made in the various steel mills. Mr. Bronson will point out the high spots in the report that is submitted this year.

Mr. C. B. Bronson (New York Central):—The report of the Sub-Committee on Mill Practice presents in brief form a record of recent improvements in the manufacture of steel rails. The widespread use of heavier sections, together with the universal adoption of the 39-ft. standard length created new manufacturing problems which are reflected collectively in the expenditure of several millions of dollars. This has been accomplished without increased cost per ton to the railroads, in the face of the expense and outlay involved, which is indeed gratifying.

Encouraging progress has been made towards greater perfection of details through the departments of the steel and rail-making plants. The heavier average and total loading imposed upon rails make strict adherence to the best standard of practice for each step in the process of manufacture imperative.

Improved conditions are indicated in that report for practically every department from the open-hearth to the finished rail. Furthermore, the mills are either rebuilding or modernizing their plants where equipment and other facilities have become obsolete or impractical for present-day requirements.

There has been a more widespread demand for special steels, particularly medium or intermediate manganese open-hearth rails; a practice which was inaugurated on the Lackawanna Railroad over seven years ago, and has proven so advantageous that many roads are now ordering sizable tonnages. Experimental installations were also made of rails made from ingots cast in hot-top molds. More advance has been made in heat treatment of rails within the past year than at any other time, and efforts have been directed towards commercializing the process for larger tonnage outputs. Methods of annealing and hotbed treatment have been under investigation, as well as further study of various types of alloying elements. Activity in these various lines is further advanced than many are aware of.

A greater measure of co-operation has been carried on between the representatives of the manufacturers and this Committee in an effort to study and solve mutual problems and arrive at basic facts in the interest of better rails for present and future service requirements.

The President:—The report on details of Mill Practice and Manufacture is submitted as a progress report. Are there any questions or any discussion? If there are none, Mr. Chairman, you may proceed.

Mr. Earl Stimson:—The two outstanding features of the activities of the Rail Committee this year are as follows:

(1) The formation of a joint committee with the Rail Manufacturers' Technical Committee for the purpose of collaborating in the study of the causes of rail failures, particularly transverse fissure rail failures, and the conducting of such tests and experiments that may lead to the determination of the causes and the elimination of such causes.

In order to carry this work on, the two Committees met as a whole during the convention last year and organized for the work by appointing a Sub-Committee from each of the two Committees to act as a joint subcommittee to outline a program of procedure and put such program into effect.

During the year this Sub-Committee had four or five meetings, at which a definite program of procedure was outlined, and that work is now being put into effect.

The Bethlehem Steel Company is co-operating with the Pennsylvania Railroad Company in furnishing rails manufactured under various conditions, some heat-treated rails, and some of varying carbon content; and the Carnegie Steel Company is co-operating with the Baltimore & Ohio Railroad along the same lines. These rails will be put in track and will be carefully watched as to service. From the results of these tests some very valuable information will undoubtedly be developed which will lead to better rails or at least give us some indication as to whether rails manufactured under certain conditions are better than those manufactured under others.

The second outstanding feature of the Committee's work has been the development of the transverse fissure detector car. This work was financed by the American Railway Association, which has furnished a little over $23,000 for the building of the first transverse fissure detector car. This car is now completed and is under test on the New York Central Railroad. The finishing touches are being put on the car and details perfected so that it will be fit for practical use on the tracks of the railroads.

We have an exhibit here which will undoubtedly became of considerable historic interest and will be carefully preserved in the archives of the Association. It is the first transverse fissure detected by this car in actual operation over railroad tracks. It will be placed out in the lobby so everyone will have an opportunity to see it.

Since the car has been completed and has been undergoing the final tests on the New York Central Railroad, Mr. C. B. Bronson, of that company, has followed very closely the tests, and he is in better position than anyone

to tell us the true story of the present status of the car and its prospects of utility in the detection of transverse fissures in rails in track.

Mr. C. B. Bronson:—The Sperry Detector Car for locating interior defects and transverse fissures in rail heads is one of the most important developments ever presented before this body. Mr. Elmer A. Sperry, who originated the idea, is unique as a scientist and inventor of many devices of great practical value. The work of development has been ably carried on by Mr. Harcourt Drake, representing the Sperry interests, and Mr. Keevil, representing the American Railway Association, and the rapid progress made in a little over one year constitutes a remarkable record.

Considerable demand has arisen for a descriptive article of this device, and we are therefore presenting in pamphlet form a condensed and illustrated brief of the general design and important details of the mechanism as well as some historical data.

The basic principle throughout all of the development work has been the air-gap effect of dissociated particles within the rail head. This is made evident by forcing a high current at low voltage through the rail head, and picking up the resistance effect from the interior fracture by a small detector coil. The minute impulse developed is then conducted to radio tubes and amplified from two to three hundred thousand times. Sufficient power is thus obtained to operate relays and pens for a permanent record on a moving strip of paper of the size and location of each fissure, spray paint against the side of the rail section, and operate a buzzer or loud speaker to further notify the operator of the test car.

The initial tests on over fifty rails at the Sperry plant consumed about six months, and were sufficiently thorough to establish the absolute correctness of the basic theory. Such a degree of proficiency was attained that the exact size and location of each fissure in the rail head could be forecast; even those one-eighth of an inch in diameter. Furthermore, it was demonstrated that fissures had to be within the rail head or else no indication developed from the sensitive apparatus; a fact which was checked many times on different rails. The location of fissures was so accurately detected that a drill could be correctly centered to pierce the top of the head down to the depth of the fissure within.

As a result of these successful practical studies, the track car was developed and has been on trial operating on specially prepared track on the New York Central at Beacon, 58 miles north of New York City, as well as in test runs on the main line high-speed tracks. Experience has necessitated numerous minor and time-consuming changes, but the work has proceeded during these past two months on a conservative and thorough basis, which is essential in any important research or development work. Great advances have been made and there seems no doubt of the ultimate usefulness of the device.

The detector car will be available for trial runs on many other lines throughout the country, subsequent to the work now in progress.

Reference has been made by governmental and other agencies to the value and importance of the Sperry Detector Device, and this Association

should be congratulated for its progressive spirit in financially aiding in the development and utilization of this remarkable apparatus. (Applause.)

The President:—Gentlemen, the speaker has just told you that this is one of the most important topics that the Committee has to present. We wish to give you an opportunity of asking questions or making suggestions or criticizing what has been presented. I hope you will feel free to say what you have on your minds.

Mr. J. V. Neubert (New York Central):—I have been interested very much in transverse fissure matters for a number of years. I was not interested in the Sperry development until I visited their plant with the Rail Committee last summer, which they kindly invited me to attend. I have since been very much interested in its development.

The New York Central East has had this car for several weeks on its tracks to develop it. A great deal of thought and consideration has been given in regard to what the expectation is of the machine. I have great faith in it. A great many people are in doubt as to what it will do. I have been on the car several times, and it does indicate, but not to the perfection in the track service as it did in their plant.

There is an old saying that "Rome was not built in a day." This is a new development, and I do not believe it will be developed in a day, but I think if we have confidence, a little patience, this machine will do what it is expected to do. I know that as far as the New York Central is concerned we do not care how long they want to leave the car there, until the Rail Committee are perfectly satisfied that it is what it is expected to be.

I just thought I would mention that because there is some question of doubt, and some may think this is a joker, but it is not. It is a new device. It is the introduction of the development of the location of the fissure trouble, and is the first device that has brought us any light since the noted Manchester wreck on the Lehigh Valley a number of years ago.

The President:—I should like to be permitted to call on some of you gentlemen to say what you think about this subject. If Major Macomb is in the audience, we would be glad to hear from him.

Mr. J. de N. Macomb (Inland Steel Company):—Mr. President, I have not had an opportunity of seeing the device in operation.

Mr. Sperry was working on the track recording car in connection with the Santa Fe some years ago when the matter of transverse fissure was brought to his attention. He was leaving for New York in a very few minutes after that. Before he reached New York on the Twentieth Century he had the detector entirely worked out on paper, in drawings as well as description, and sent them back by return mail. The drawings had just reached here when we had a telegram from him to disregard the whole thing, that it was made up on the magnetic principle, and he wished to change to the electrical principle, which he subsequently did.

I think the Santa Fe would have been glad at that time to have gone forward with the development of the detector except they were then engaged in the development of the track recorder.

Some time elapsed after that before the development of the detector was taken up by the Committee, and since then I think we are all familiar with the history of the device.

As I said, I have not had an opportunity of seeing the detector in operation for the past few months, but personally I am absolutely satisfied that with a little development work and ironing out the imperfections which are sure to occur in any new device, the detector will be a great success.

The President:—Is Mr. Baldridge of the Santa Fe in the room?

Mr. C. W. Baldridge (Santa Fe):—Mr. Chairman, personally, I have not had anything to do with, or have not seen the Sperry detector car. It is a very interesting method, and certainly one to be very much commended, producing a means which will determine whether transverse fissures are located in the rails, whether or not they are visible before they break.

In this connection, however, I think it is only fair to give credit to a present member of the Rail Committee for pioneer work on this line. Mr. E. E. Chapman, who is now a member of the Rail Committee, started the investigations of a rail transverse fissure detector, using a magnetic scheme, which showed the presence of transverse fissures without a question, but, unfortunately, it was affected by any irregularity in the top of the rail to such an extent that it gave many false indications, and consequently did not prove effective. From that start the present rail detector has grown.

The President:—If Dr. Unger, of the Carnegie Steel Company, is in the audience, we will be glad to hear from him.

Dr. J. S. Unger (Carnegie Steel Company):—Mr. Chairman, I am interested in the further developments of the transverse fissure detector car.

I am awaiting, with a great deal of interest, word from the Committee that will advise us that the car is ready to go out into service. I believe we can find enough work for the car to do when the Committee have put their O.K. on the car.

Our people have for many years aimed or tried to develop an instrument of some sort that would show the presence of transverse fissures in a rail. We spent considerable time and money in trying to further develop the magnetic method.

Those who have had experience with that method know that it would not meet all the conditions that were required in order to detect a fissure in a rail.

I can add very little, Mr. Chairman, other than to say the manufacturer is interested to the same extent that the railroad is, in the future development of the Sperry transverse fissure detector.

The President:—If Dr. Talbot is in the audience, we will be very glad to hear from him.

Dr. A. N. Talbot (University of Illinois):—I am also very much interested in this instrument. I have not known anything about the details, so I am not competent to comment on it. From time to time, when the matter of a detector for transverse fissures has been discussed, the question has been raised as to whether an instrument would be able to distinguish between, say, a transverse fissure and other defects or other lack of homo-

geneity in the rail. I should be pleased myself to have the Committee say whether this instrument as it has been devised will surely distinguish between one kind of a defect and another.

Mr. C. B. Bronson:—The basic principle of this device is the discontinuity or rupture within the rail head. As long as there is a break or separation of the particles within the head—either entirely transverse, or partly longitudinal and partly transverse—this apparatus will absolutely pick up the defect.

The air-gap effect of dissociated or broken particles is the basis upon which the entire equipment has been developed.

In connection with the record that is shown in the mounting, I should like to call attention to the fact that the actual record from the apparatus is shown directly above the three fractures. This record is one of four or five duplicates that were made on this stretch of track, indicating that the record can be repeated without difficulty and that the indications are absolutely identical from one record to the next.

The President:—We find that American Railway Engineers are not the only ones who are making a study of these defects in steel rails. Japanese Engineers have done some work along this line. We have present with us this morning M. Suzuki, Mechanical and Research Engineer of the Japanese Government Railways, Tokio, Japan. We would be very glad if he would tell us something about the work along this line that is being done by Japanese Engineers.

Mr. M. Suzuki (Japanese Government Railways):—I regret that I am not prepared to make an address to you this morning.

The President:—We hope you will be back next year after this Committee has done more work on transverse fissures, and we hope you can tell us what your government is doing then. We would be glad to have you come back next year and tell us what you are doing.

Mr. G. H. Tinker (New York, Chicago & St. Louis):—I should like to ask if it is the thought of the Committee that the use of this machine will throw any light upon the cause of the formation of these fissures originally, and whether it is also the thought that the machine will be further developed so that it may be available for use in the mills, before the rails are put into track, for the detection of incipient fissures.

I understand from a remark of Mr. Bronson that the basis of the action of the machine is the presence of an air gap, perhaps not an actual separation, but an incipient separation. I judge from that that there would be absolutely no difference in the indication between a transverse fissure and what we call a pipe or longitudinal fissure in the rail. I should like to ask if that is a fact.

Mr. C. B. Bronson:—The machine will not detect a pipe on account of the fact that the pipe is longitudinal and the fissure is transverse. Transverse dissociation within the head is essential.

The other point that the gentleman has just raised as to the possibility of the utilization of this principle for determining the cause of fissures in new rails is under very careful consideration, but it naturally must be

taken up in easy stages, and the first development necessary was to attack the large problem of attempting to locate fissures in rails in service, to aim for their removal as rapidly as possible, and subsequently will come the development of the device for new material. That is now under very careful consideration by Mr. Sperry.

Mr. Earl Stimson:—I wish to call the Association's attention to an illustrated description of the transverse fissure car which was issued as a supplemental report of the Committee. This has been placed on distribution in the lobby.

I also want to express appreciation for the aid that the New York Central Lines, through Mr. Neubert and Mr. Bronson, have been to the Association and the Rail Committee in the final tests of this car. After it was completed in the shop, the question arose as to what sort of a road test we would give it. The New York Central people very kindly offered to place their tracks at the disposal of the Committee and the Sperry people for the test. Without this it would have been very difficult to have determined the practicability of the car. While it worked perfectly in the laboratory, when the machine was put on the car and propelled along the track, very many difficulties arose that were not encountered in the laboratory. The fact that the car has now been out on the road in tests for over sixty days will give you some indication of the magnitude of the service that the New York Central have rendered, and also the debt the Association owes that company.

The Rail Committee this year have no recommendations to offer for adoption. The report is one of progress and is submitted as information.

The President:—During the year a Committee of the Board of Direction has compiled statistics on the work done by the various working committees. There will be distributed to you this morning a pamphlet which deals with convention procedure. You will notice an exhibit attached to that pamphlet showing the apparent amount of work that has been done by each of the working committees since the Association was organized. I just want to refer to the work that has been done by the Rail Committee. Since the Association was organized this Committee has presented twenty-seven reports for your consideration. Those reports contain 3,892 printed pages. For all the reports presented to the Association during that time, the total was 23,000, or, in other words, the Rail Committee has contributed 16 per cent of the total volume of reports submitted to you.

As to the discussion of these reports, the Rail Committee's work represents 251 printed pages out of a total of 3,379, or seven per cent of the total discussion on all reports submitted to you.

This Committee has worked very industriously from the time it was organized, and the work it is doing at the present time is probably the most important topic for consideration of this Association.

The Committee is dismissed with the thanks of the Association. (Applause.)

DISCUSSION ON ROADWAY

(For Report, see pp. 525-555)

(Past-President Edwin F. Wendt in the Chair.)

Mr. C. W. Baldridge (Santa Fe):—The report of the Roadway Committee is to be found on page 525 of Bulletin 303.

The subjects assigned the Committee were published on page 2 of Bulletin 296 issued in June, 1927. Therefore, they are not repeated in detail here, but are reported by number and title only.

As a result of the year's work, the Committee respectfully presents and recommends action thereon as follows:

Subject No. 1, Revision of the Manual. The report of the Committee is given in Appendix A, and since no revisions of the Manual are offered, no action is recommended.

Subject No. 2, Study of Corrugated Metal Culverts. The report of the Committee is given in Appendix B. The Committee offers the report as information and requests that the subject be reassigned.

Subject No. 3, Study of Deformations of Roadbed. The report of the Committee is given in Appendix C. The report is offered as information and it is recommended that the subject be reassigned.

Subject No. 4, Study of Improved Methods for Preventing Corrosion of Fence Wire. The Committee reports progress and asks that the subject be reassigned.

Subject No. 5, Study of Specifications for Steel Fence Posts. The report of the Committee is given in Appendix E. The Committee recommends that the specifications for metal fence posts be adopted for inclusion in the Manual, and that the subject be discontinued.

Subject No. 6, Permanent Roadbed Construction. The report of the Committee is given in Appendix F. The report is offered as information, and it is recommended that the subject be reassigned.

Subject No. 7, Methods for Policing the Right-of-Way. The report of the Committee is given in Appendix G. The report is offered as information and it is recommended that the subject be discontinued.

The lack of revision of the Manual this year does not mean that this Sub-Committee were idle during this year, for in addition to the revision of the Manual, Mr. Oyler, who was made Chairman of the Sub-Committee, and his Committee, have represented the Roadway Committee on all collaboration work of this Committee with other committees. Mr. Oyler is not present to-day and there was nothing to report, therefore we will not go into that subject any further.

The second subject assigned to the Roadway Committee reads: Continue the study of Corrugated Metal Culverts. The Sub-Committee in charge of this subject have done some hard work this year, as you will find by reading Appendix B. Mr. W. H. Woodbury, the Chairman of the Sub-Committee, will present the report.

Mr. W. H. Woodbury (Duluth & Iron Range) :—I think before I say anything about our present report, I might review briefly the purpose and the outline of the work of this Sub-Committee.

This Sub-Committee has been in existence some twelve or fifteen years. I have been associated with it personally for about ten years. In attempting to make a study of this subject, we approached it from three angles: First, durability; second, strength, and third, the economics of such structures.

The question of durability has corrosion and wear to consider. The question of corrosion is a question that can be determined only by long periods of time. We have records of culverts in use twenty and more years. The majority of them run from twelve to twenty years. Every five years we have been making a reexamination of the condition of the culverts which we have been inspecting, so in 1930, if this Committee continues, they will probably have further reports to make on the culverts that have been reported on in the past.

With regard to strength, as you all know, we have put on a series of tests on the Illinois Central Lines in Southern Illinois under a 35-foot bank and by means of the Goldbeck cells have been reading the pressures developed on these culverts, and in our last report we made a rather full report of what we discovered.

In the last year we have undertaken to study the stresses developed in the metal of this type of culverts. We have met with a great deal of difficulty. A flexible culvert becomes deformed under pressure. That means that there is a yielding in the metal, and after the yielding, the stresses are entirely different from what they were before the yielding. This precludes the use of the extensometer and other devices for reading stresses.

Some members of the Sub-Committee who were qualified to do so, have been making some very elaborate mathematical studies. I do not happen to be one of those members.

This report is largely a compilation of the information which has been gathered together from various sources. Dean Marston is probably the author of most of this information that we have compiled. I wish to say that this report as shown in this Bulletin represents only a small fraction of the amount of work that has been done. Some day we may ask the Board of Direction to allow us to print a booklet showing the many computations and assumptions that have been made in an attempt to arrive at some formula by which the strength of these culverts can be determined so that designs can be made according to standard lines.

As yet we have really reached no definite conclusions. This material here is presented as information only.

Now as to the third element in this problem, which is the economy of such structures, we feel that it cannot be determined until such a time as we have been able to determine something of the life of such structures. We can determine whether a structure of this type will cost more in the initial installation than other types of structures, but as to whether it is more

economical to use this type as compared with the others, cannot be determined until we know something of the life.

When that time will occur, I do not know. We may venture an estimate sometime as to that and bring in a report and ask that the subject be closed out, but as yet we are not prepared to do so.

I believe, Mr. Chairman, that is all I have to say.

Past-President Edwin F. Wendt:—The Committee presents a progress report only, but it would like to have general discussion, and the subject is now open. Does any member desire to discuss corrugated metal culverts? If not, the Chairman will proceed with the next subject.

Mr. C. W. Baldridge:—The third subject assigned to the Committee reads: Continue the study of deformation of the roadbed, in the light of data developed by the Special Committee on Stresses in Railroad Track, with special reference to its effect on track maintenance. The report of this Sub-Committee is found in Appendix C on page 543 of Bulletin 303. Prof. Vawter, Chairman of the Sub-Committee, will present the report on this subject.

Prof. Jamison Vawter (University of Illinois):—With regard to the effect upon track maintenance, the Sub-Committee has not been able to get any figures on maintenance. The first endeavor was to get these figures from members of their own personnel but they were not able to get sufficient figures to use to any advantage, and so nothing has been done on that part of the subject as yet. The intention is to get these figures by means of a general questionnaire.

In studying the remedies, the Committee considered drainage, deeper ballast, and concrete slabs. They felt adequate drainage was the most important requirement for any roadbed. There were no conclusions reached on slabs because the total cost is tied up in the question of maintenance, that is, the relative maintenance costs of the track that is carried on ballast, on concrete slabs, or deeper ballast sections will affect the total cost.

The general conclusions of the Committee are given on page 544 of the report and are that in general roadbed deformations may best be eliminated by first preparing the roadbed to stand a reasonable load, and second, applying such a depth of ballast as to so distribute the load applied that the pressure per square foot will not be greater than the capacity of the roadbed.

In that connection we might refer to the 1920 report of this Committee in Appendix D of that report in Volume 21 of the Proceedings, in which the pressure to be expected at various depths of ballast was given. Those figures were obtained, I understand, by the Chairman of the Sub-Committee at that time, consulting with Dr. Talbot, in the light of the information that had been obtained by the Special Committee on Stresses in Track.

The figures they gave were that for 12 inches of ballast, under static load, the maximum pressure realized would be about 2.75 times the average load over a width of roadbed equal to the length of the tie. For 18 inches of ballast it would be 1.6 times the average load over that same area, and for 24 inches of ballast the pressure would be about equally distributed over an

area of about 6 inches wider than the length of the tie. That was based on 8 or 8½-foot ties and on spacing of 21 inches.

Past-President Edwin F. Wendt:—The subject is now open for general discussion. Does any member desire to discuss this matter of deformation of roadbed? If not, the Chairman will proceed with the next subject.

Mr. C. W. Baldridge:—The fourth subject assigned to this Committee reads: Continue the study of improved methods for preventing corrosion of fence wire. The Sub-Committee which had charge of this subject were unable to complete the subject in this year's report. However, Mr. Swartout, the Chairman of the Sub-Committee, will tell you something of the work they have done.

Mr. W. C. Swartout (Missouri Pacific):—Sub-Committee No. 4's work during the past year has been confined almost entirely to seeking an avenue of approach to the subject assigned which would yield some worthwhile and tangible results. We find that the American Society for Testing Materials, Committee A-5, is, along with other subjects, carrying on an investigation of this same subject. We are working in close collaboration with that subcommittee, which is styled "Sub-Committee VIII on Field Tests of Metallic Coatings."

Test racks for the exposure of corrugated galvanized iron sheets of various types of iron, for the exposure of wire and of woven fencing, have been arranged for, but the fencing has not yet been put up, as all samples have not been received.

It may be of interest to our Association to know something of the details of this test and I am quoting the following from the report of Sub-Committee VIII of Committee A-5, A. S. T. M. for 1927, for 1927. "At present there will be erected a sufficient number of test racks to give a fairly representative cross-section of the atmospheric conditions met by metallic coated products. These conditions may be generalized as a severe industrial atmosphere, a moderate industrial atmosphere, a pure rural atmosphere, a foggy temperate seacoast atmosphere, and a humid seacoast atmosphere. The committee secured locations where the atmospheric conditions approximate those desired, with the understanding that the specimens will remain undisturbed for at least twenty-five years.

"The rack exposed to the severe industrial atmosphere is located at Brunot Island, in the Ohio River, about two miles west of Pittsburgh, Pennsylvania, on the property, and through the courtesy, of the Duquesne Light Company.

"The moderate industrial exposure is located at Altoona, Pennsylvania, on the roof of the storehouse of the Juniata shops, through the courtesy of the Pennsylvania Railroad.

"The rural exposure is located on the grounds of the agricultural department of the Pennsylvania State College, State College, Pennsylvania, about one and one-half miles from the college buildings. The racks were erected through the courtesy of the officials of that college.

"The foggy seacoast exposure is located within the government reservation at Fort Hancock, Sandy Hook, New Jersey, through the courtesy of the United States War Department.

"The tropical exposure is located within the reservation of the United States Naval Station at Key West, Florida, through the courtesy of the U. S. Navy Department.

"The posts at State College are concrete fence posts. There are two lines of posts of eight 16½-foot bays. The posts at Sandy Hook, Key West and Brunot Island are galvanized iron angles embedded in concrete because the concrete posts were so damaged in transit that it seemed undesirable to erect the racks in this manner, while the Altoona rack consists of galvanized angles as originally designed.

"The erection of these racks was carried out by a crew supplied by the Pennsylvania Railroad and the New Jersey Zinc Company, except the Key West rack which was erected by the Navy Department."

On behalf of our own Committee, we propose to supplement the data secured from these test racks of Sub-Committee VIII by securing data as to the kinds of fence wire, both barb and woven, in use by railroads, securing all data possible about past performances of various kinds of wire in as many different parts of the country as may be possible, and to this end we would most urgently request that you give the questionnaire, which will be prepared, upon which the data will be built, most careful study, since any conclusions of value will necessarily be of benefit to all of the railroads represented in our Association.

A study of wire in general use will, perhaps, give us better information than we may get by waiting for results of tests on small amounts of different kinds of wire, especially when we realize that a considerable length of time must elapse before definite results will be available, while on the other hand each railroad here represented has in service various kinds of fencing for lengths of time long enough to give it a condition at the present time varying from new to complete failure.

The Committee was unable to get the data together in time for the report and we would respectfully request the reassignment of the subject for next year.

Past-President Edwin F. Wendt:—The subject of corrosion of fence wire is now open for general discussion.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—In the early days in the use of fence wire the first kind we purchased was a flat wire with a barb fastened on by a straight turn over the plain edges with the point going out, called at that time the Thorn Wire Hedge, manufactured by the Washburn-Moen Company. We applied a good deal of that wire to our fences about forty-four years ago. We still have a good many fragments of that fence in use, and samples of it when examined show very little corrosion.

I have submitted one or two samples to this Committee for comparison and also had analyses made of the steel and the galvanizing, and all

sources to whom I have referred it have arrived at the conclusion that the long life of the metal was due to the honest galvanizing.

Past-President Edwin F. Wendt:—Is there any further discussion? If not, the Chairman will take up the next subject.

Mr. C. W. Baldridge:—Before leaving this subject, I want to say a word for this Sub-Committee. Mr. Swartout is one of the Missouri-Pacific Engineers who had a great deal of work to do in the Mississippi Valley as a result of the flood this year. That had a good deal to do with our not being able to give you more this year than we have.

Subject No. 5 as assigned to this Committee reads: Continue the study of specifications for steel fence posts. The report of this Sub-Committee will be presented by Mr. Botts, Chairman of the Sub-Committee.

Mr. A. E. Botts (Chesapeake & Ohio):—The report of Sub-Committee 5 is found on page 544 of Bulletin 303, Part 1. The Committee offers as information the introductory matter on pages 544, 546, and the chart on page 545, which was the only test of metal posts secured.

On account of the wide variation in metal fence posts now in use, the Association will readily understand the difficulty of preparing a satisfactory specification to cover.

Further study of the subject since our report was submitted for printing in the Bulletin causes us to recommend the following changes: At the top of page 547 under heading "Material," the entire paragraph be changed to read: "Metal fence posts may be made of steel or wrought iron, or alloys of iron of any kind which will pass strength tests as described below." And the paragraph as formerly written be inserted as information on page 546, after the paragraph under heading "Advantages."

Page 547, "Strength," be changed to read: "Material used for fence posts shall have a minimum tensile strength of 40,000 lb. per square inch, and with a finished post, clamped rigidly, a load of 300 lb., applied at three feet from the face of the clamp, the deflection shall not exceed six inches and the permanent set shall not exceed two and one-half inches. The load for this test shall be applied to the face of the post against which the fence material bears."

Page 547, "Ductility," be changed to read: "A finished post resting upon supports five feet apart, and with a load applied at the center, must withstand bending eight inches from a straight line, with no signs of failure."

Tubular Posts, the cold rolling of tubular posts is sufficient test for ductility, therefore tubular posts are exempt from the ductility test.

Page 547, "Workmanship," be changed to read: "All posts shall be smoothly rolled or formed and shall be straight throughout the length. Each finished post shall be free from burrs or other deformation caused by fabrication. They shall also be free from slivers, depressions, seams, crop ends and evidence of being burnt. (The above does not refer to rough places caused by zinc coating when galvanized.) Variations in length shall not exceed ½ inch over or under the prescribed length. Variations in other

dimensions shall not be more than $\frac{1}{16}$ inch over or under the prescribed figures."

Page 547, "Coating," remains as written.

Page 547, "Special Fabrication for Line Posts," remains as written.

Page 548, "Special Fabrication for End, Corner and Gate Posts," remains as written.

Page 548, "Weight," remains as written, except substitute "1.30 lb. per linear foot" for 1.40 lb.

Page 548, "Inspection," remains as written.

I move that with the above changes, the specifications for metal fence posts be accepted for inclusion in the Manual.

Past-President Edwin F. Wendt:—The motion is that the specifications for steel fence posts as modified by the statement of Mr. Botts be approved and published in the Manual. The motion is now open for general discussion.

The Committee has prepared the complete specifications as revised, and they are presented in blueprint form, copies of which are available at the table.

Are you ready for the motion?

Mr. J. L. Campbell (Southern Pacific):—I believe that the Association has a specification for galvanizing. If that is true, I wish to ask the Committee if there is a reason for this particular specification for galvanizing.

Mr. C. W. Baldridge:—I do not know that there is any special reason for this. I expect that it is a case of going through the prepared specifications without giving sufficient consideration to the fact that there are other specifications covering that point. I did not know that there were such specifications in the Manual.

(Mr. Baldridge then quoted the specifications for galvanizing appearing on pages 889-890 of the 1921 Manual.)

In the light of this matter already in the Manual, I think the Committee will agree that we substitute for the matter under the heading of Coating, "All galvanizing shall be done as per specifications on galvanizing now in the Manual."

Mr. Hunter McDonald:—I neglected to say in my previous remarks that the wire I referred to had the barb fastened on the wire before galvanizing and its appearance was rough. Evidently it had not been wiped after galvanizing. My understanding of the present methods of manufacture of woven fence wire and also of barbed wire are that the twisting and fastening and weaving is done after the wire has been galvanized, and that the wire after dipping is wiped, and the surface is smooth. I believe the railroads can get a much more durable wire if they are willing to pay for it, and will have it galvanized, without any wiping, after it has been manufactured.

Past-President Edwin F. Wendt:—Is there any further discussion? The Committee accepts the suggestion offered by Mr. Campbell and desires to modify the specifications so that their recommendation will now be in conformity with that portion of the Manual read by Mr. Baldridge.

Are you ready for the motion? All those in favor of the adoption of the specifications for steel fence posts as now proposed by the Committee for publication in the Manual will please say "aye"; contrary "no." The motion is carried, and it is so ordered.

Mr. Chairman, you may proceed.

Mr. C. W. Baldridge:—The sixth subject assigned to this Committee reads: "Continue the study of Permanent Roadbed Construction." The report on this subject is given in Appendix F, page 548 of Bulletin 303. The report will be presented to you by the Chairman of the Sub-Committee, Mr. Bayer.

Mr. E. J. Bayer (Peoria & Eastern):—The report on Permanent Roadbed appears in Bulletin 303, pages 548 to 550, and is a joint report, as the Track Committee was assigned a somewhat similar subject. This report contains information on the Pere Marquette installation as observed by the Committee from an inspection and also a later report on its condition by Mr. Chipman. The Pere Marquette and the New York Central are now keeping data on the costs of maintaining their respective types of construction, and the Committee hope to be able to give a comparison of costs next year.

Past-President Edwin F. Wendt:—The Committee submits this report as information, but it is one of the most important subjects before railway Engineers to-day, and I can testify from personal attendance at the conventions during the past twenty-nine years that this subject has been under discussion for a similar number of years and even more.

Does any member desire to discuss the Committee's progress report?

Mr. Paul Chipman, of the Pere Marquette, has done a great deal of work in the matter of design of permanent roadbed, and I am going to ask him if he cares to say a few words at this time.

Mr. Paul Chipman (Pere Marquette):—I have nothing much to offer beyond my report, which is embodied in the Committee's report.

The Pere Marquette installation is a quarter of a mile long and consists of 34 39-foot slabs. It is 21 inches thick, 10 feet wide, and quite heavily reinforced with a specially designed light truss under each rail. It has been in service for almost 15 months.

Out of the 34 slabs there are 4 which have developed slight hair cracks that extend the full width of the slab. One of these marks a construction joint in the first slab, which was not finished the first day. It is about 10 feet from the end of the slab. The other 3 cracks are near the center of the slabs. Levels show no deflection at these cracks, so there is no conclusive evidence as to whether they are due to deflection or to temperature stresses.

In regard to the rail, the batter appears to be no more than it would have been under the same amount of traffic on ordinary track. Measurements of batter were taken in December. I have not the figures at hand, but only a small proportion showed any batter whatever. One joint measured $\frac{3}{64}$ of an inch. Several showed $\frac{1}{32}$ and a somewhat larger number showed $\frac{1}{64}$. It shows up very well in comparison with ordinary track.

We had some trouble with the insulation, but that has been remedied by placing a good quality of insulating fiber under one rail for the entire length of the test section. The other rail rests directly on the concrete. Since that change was made there has been no trouble with signals. Any trouble in regard to insulation may easily be remedied by a slight change in design.

We feel that the question as to whether or not there must be resilience in the roadbed has been pretty well settled by our experience thus far. If the roadbed can be kept smooth, I believe we may conclude that no resilience is required, and that the more rigid it is the better.

We have had very little trouble with creeping of rails. The rails were thoroughly anchored on each side of this test section and creeping on the section itself has been very slight.

I might explain the method of attachment. It was by bolts and ordinary rail clips. The bolt, with the head up, engages a nut beneath a stirrup which is imbedded in the concrete. Some of these bolt heads snapped off, particularly at the end of the section, where the track support changes from ordinary ballast to concrete. There is more vertical movement of the rail at this place and this has resulted in the snapping off of a number of bolt heads. Several others snapped off at other places, but they were mostly defective bolts. We have very little trouble from that source now.

Prof. S. N. Williams (Cornell College) :—I wish to express my appreciation of the valuable report, but am especially impressed with the value of Appendix G. It is very certain that every passenger on every railway, whatever else he may or may not see, will be impressed by the appearance of the roadway and will form a distinctly favorable or unfavorable impression therefrom, and I thank the Committee for having called attention to it in such a valuable way.

Past-President Edwin F. Wendt:—Is there further discussion of the question of permanent roadbed?

Mr. Robert H. Ford (Rock Island) :—Because of the importance of the subject and in justice to the work of this Committee, I think there ought to be a greater response from the convention. There is a splendid opportunity for original research on the questions here presented.

Mr. Hunter McDonald:—I read the report of the Engineer who had charge of the test on the Pere Marquette, and I was particularly interested in the difficulty he found in measuring the batter at some points and his calling attention to the fact that the batter at certain points was due to one rail of the joint being somewhat higher than the other, which is a matter entirely due to the tolerance in the rails. He suggests the grinding down of the rails so as to equalize the two surfaces. I think that matter is one which will have to receive careful attention, but the matter of tolerance is something we can't get away from. If we have got to have perfectly smooth track in order to have permanent track, then the surfaces of the rail must be brought together by grinding after laying and not at the time the rails are rolled. These tolerances often occur in opposite directions at the same joint, and furthermore, the matter

is complicated by the tolerances existing between the fishing surfaces of the joint bar and the rail to which the joint bars are attached. The matter is one that I do not believe we will ever be able to absolutely regulate within an economical cost.

Dr. A. N. Talbot (University of Illinois) :—The question was asked by the Chairman, I believe, whether there was a field for research in this form of permanent roadbed. I take it that in an installation, such as that of the Pere Marquette, Mr. Chipman will make systematic observation on the conditions of the track along the lines that have been referred to by him, and that there will have to be developments in track fastenings, bedding of the rail and other details, and that a long time will be necessary before such questions as rail wear, need of resiliency and defective surface conditions can be answered with certainty.

There seems to be, however, an opportunity here to learn whether the rail stresses differ in some marked way from those developed with the ordinary rail support, and, if they do, it may follow that a different shape of rail with a different distribution of metal would better fit the conditions, these new conditions, and whether there is need of increase in the weight of rails in certain parts of the section and even whether all in all a relatively lighter section may be suitable. An advantage of this kind does not appear very probable, but a definite conclusion can be established only by tests.

In the report a year ago stress was laid on the value obtained in reducing the train resistance on track laid in this way. I had hoped there could be some report made on what differences in train resistance exist on the two kinds of track. I realize the difficulty of determining this with the short section of track available. The ordinary dynamometer car would not be applicable perhaps, and yet I can see the possibility of using two or three heavily loaded cars and pulling with some kind of a dynamometer at slow speed in a way that might determine differences. I hope the railroad company will be able to make such tests.

Past-President Edwin F. Wendt:—This subject will come up again next year, and owing to the lack of time we will now take up the next subject.

Mr. C. W. Baldridge:—The seventh subject assigned to the Committee reads: Proper methods for policing right-of-way with special reference to appearance and economy of maintenance. The report on this subject is found in Appendix G, page 553 of Bulletin 303. In the absence of the Sub-Committee Chairman, Mr. Anderson, the report will be presented by Mr. Hillman, a member of that Sub-Committee.

Mr. F. W. Hillman (Chicago & Northwestern) :—The Committee has attempted to give a definition of policing and to show that general correspondence indicates the policing of right-of-way is a pretty general practice. The work involved is outlined briefly, and attention is called to the fact that this question of policing should be considered during the early construction stages so as to make it somewhat easier for the maintenance forces later.

There were some suggestions given for carrying out the different problems of policing, and attention has been called, as Professor Williams has just stated, to the policy so far as the public is concerned.

We were only able to get one example for comparing costs, and that is given on the bottom of page 554. This report is submitted as information.

Past-President Edwin F. Wendt:—Is there discussion?

Mr. W. H. Woodbury:—In making my oral report on Corrugated Metal Culverts, I omitted to give a little credit that I wish to give. I would like to have these remarks considered as an insert after what I said before.

I want to give credit to Professor Vawter, the gentleman sitting at my left, as the man who has done over 90 per cent of the work for this Sub-Committee. He has done a great deal of work that is not shown here, and has obtained collaboration with several other men of special mathematical training, and it is through him and these other gentlemen that we have the report we have today.

Mr. C. W. Baldridge:—This closes the report of the Committee on Roadway.

Past-President Edwin F. Wendt:—The Committee on Roadway is the oldest Committee in our Association. It has done most excellent work and is now excused with the thanks of the Association. (Applause.)

DISCUSSION ON MASONRY

(For Report, see pp. 605-640)

Mr. C. P. Richardson (Rock Island):—The report of the Committee will be found on pages 605 to 640 in Bulletin 303.

The Committee has devoted the greater part of its attention, during the past year, to a continuation of the study of the principles of design of concrete and reinforced concrete, with particular reference to the Joint Committee's report on Standard Specifications for Concrete and Reinforced Concrete, which was published in Bulletin 269, during September, 1924. It presents a progress report on this subject, and includes a Specification for Flexure of Reinforced Concrete T-Beams and recommends its adoption by this Association.

It also reports progress on other subjects under this classification.

It reports progress on methods of concrete manufacture, specifications for foundations and on general practice in the waterproofing of railway structures.

I will ask Mr. Hirschthal, Chairman of the Sub-Committee, to present the subject-matter of Appendix A on Principles of Design of Concrete.

Mr. M. Hirschthal (Delaware, Lackawanna & Western):—The Sub-Committee on Design at the beginning of the year laid out for itself a program that was very ambitious, but which it hopes in the not distant future to carry to completion. This program is to lay down principles of design for every type of concrete or masonry structure.

At the present time the Committee presents the principles of design of T-beams for your approval and for adoption to be printed in the Manual. The Committee, where possible, followed the recommendations of the Joint Committee, and only where this procedure was in conflict with practice on railroad design have we made any changes, or where the wording was somewhat ambiguous have we made a change in the present structure of the recommendations of the Joint Committee. I therefore move for the adoption of this section for printing in the Manual, and will proceed to read by sections, waiting for comments, if the President approves of this procedure.

The first subject is Flexure Formulæ, paragraph 137. There is a slight typographical error of arrangement rather than typography. The footnote at the bottom should be asterisked after the words "See footnote." That should be followed by an asterisk, and the asterisk at the bottom of the page followed by "Position of neutral axis" should be above the formulæ. Otherwise, this stands as printed.

Notation, General, Flange Width and Thickness, Transverse Reinforcement, Compressive Stress at Supports of Continuous T-Beams, Shear. This completes the subject of T-Beam Design.

The President:—It has been moved and seconded that the recommendations appearing on pages 607 and 608 and the first three paragraphs on page 609 be adopted for publication in the Manual. The question is now open for discussion. Are you ready for the question?

Those in favor of the motion will say "aye;" opposed "no." The motion is carried.

Mr. M. Hirschthal:—The remainder of pages 609 and part of 610 is given over to the subject of Concrete Encasement of Steel Members.

It has been the custom in the design of this type of construction to figure the structural steel as carrying the concrete as dead load only. Tests have recently been made which tend to indicate that this is not a fact, that the dead load of the concrete is not simply dead load but aids in carrying the composite structure as a composite member. The Committee felt, however, that there was not enough data given in these tests to justify any conclusive result.

We, therefore, recommend a further study of this subject, giving the bibliography with a number of monographs and the results of tests in the printed matter on pages 609 and 610. This subject is given as information only.

This is followed by the subject of Pre-Molded Concrete Piles, in which the Committee has attempted to give some idea of the method adopted to approach the design of concrete piles for various purposes. A figure is given on page 611 showing a typical design. This is also given as a matter of information.

We now come to the subject of Concrete Columns. The design of concrete columns has been the subject of more prolific discussion by the profession than has any other subject. There has been more disagreement on this subject than on any other. The Committee has gone into, as thoroughly as is physically possible, the subject, but has failed to arrive at an absolutely unanimous conclusion, and therefore does not make a positive recommendation for inclusion in the Manual. It, however, requested the printing of the subject-matter of Professor Withey's conclusions of his tests into this Bulletin so as to give the membership of the Association an idea of what has been done on this subject. It hopes that in this manner we will invite discussion, constructive criticism and information which will lead to a final conclusion, leading to a design of column which will be accepted by all professional men designing this type of structure.

This also is given as a matter of information and is not recommended for inclusion in the Manual.

On page 616 the subject of Arches is briefly discussed with the recommendation as to the manner of designing arches. That is also given as information, pending further developments on this line. There have been recently designed reinforced concrete arches by the rigid frame method which disregards the elastic theory in so far as it does not contemplate absolutely rigid abutments of piers. This is also given as a matter of information.

On page 619 is a monograph by the speaker on flat slab regulations. The Committee found it could not agree with regulations laid out by the Joint Committee in its recommendations, in so far as it felt that these regulations applied more specifically to buildings than it did to railroad structures.

On the other hand, we were not able to provide a substitute fittingly to cover all cases. It was therefore decided to have printed in this Bulletin this monograph of the proposed regulations for flat slab structures.

I might say at this time that these regulations are used by the Delaware, Lackawanna & Western Railroad in its design of this type of construction. This is also given as a matter of information.

At this point I should like to point out some typographical errors. In the first paragraph near the end "sheers" should have been spelled "s-h-e-a-r-s." In the last paragraph, "For slabs with drop panels the slab thickness may be assumed as obtained from formula t_2," the "C" should be "c", so as not to conflict with the "C" up above. The same applies to the formula at the top of page 620, where the "t" should be "t_2" and the "C" should be "c." This is also recommended as information and not for inclusion in the Manual.

This completes the report of the Sub-Committee on Design.

The President:—The Committee presents Concrete Encasement of Steel Members, Steel Encased with Concrete, Pre-Molded Concrete Piles, Reinforced Concrete Columns, Arches and Regulations for Flat Slabs as information.

I know the Committee would welcome any suggestions or criticisms you may have to make on any of these subjects. We will be very glad to hear from you at this time. If there are no suggestions, these reports will be received as information.

Past-President J. L. Campbell:—This is a very interesting and important subject, and I am inquiring whether this Association is represented on the Joint Committee on Concrete. This, as you all know, I presume, is a subject that has been under intensive study for a good many years by this Joint Committee, which is doing a vast amount of scientific work in this connection, and it occurs to me that the work of this Association in this particular ought to have the advantage of the work of the Joint Committee.

There is also a question in my mind whether this Association should undertake to set up specifications of its own in a matter of this kind unless there is special reason. In may be true that the American Railway Engineering Association should have complete specifications covering the field of reinforced concrete design, if necessary in our judgment.

This is not a new question in this Association. I am just raising the question here now, making the suggestion that any work that we do along this line should give proper consideration to what is being done by the Joint Committee.

Mr. M. Hirschthal:—In answer to Mr. Campbell's question, I wish to say that we have five members of this Association as members on the Joint Committee. In 1926 the same subjects were discussed, and in the 1927 Proceedings was presented a monograph by the speaker on Flat Slabs, and another by Mr. Condron on Columns, which were voted to be presented to the Joint Committee for their discussion and information.

It appears that there has been no meeting of the Joint Committee since that time. We have not heard from them. At the beginning of 1927 we

also called the attention of the Joint Committee to the fact that we were discussing this matter again. The members on that Committee are Mr. Hadwen, Mr. Yates, Mr. Westfall, Mr. Schall and Mr. Boyd. They are all members of the Masonry Committee.

Incidentally, I omitted to say that the T-beam regulation has met the approval of the Committee on Buildings.

The President:—Are there any further suggestions? If there are not, Mr. Chairman, you may proceed.

Mr. C. P. Richardson:—I should like to add a few remarks to what Mr. Hirschthal has made on Appendix A, with particular reference to the second subject, or the Encasement of Steel Members. I draw attention to Section 2c, page 605, which reads: "That the Board of Direction take under advisement the formation of a Joint Committee of Affiliated Engineering Societies to make a study and report on 'The Concrete Encasement of Steel Members.'"

I believe, and the Committee believes, that this particular subject is one which touches our financial outgo every year; year after year, the designing engineers, following the present codes and practices, have problems in the redesigning of beams to carry the dead load, due to encasement. The tests that the Committee have studied very clearly indicate there is considerable question. The answer to that question may mean the saving of a good deal of money to the railroads if some advantage can be taken of this concrete encasement.

The President:—I wish to say that the Board of Direction will take the suggestions of the Masonry Committee under advisement and try to work out something.

Mr. C. P. Richardson:—Appendix C, pages 621 and 622, presents a progress report on methods of concrete manufacture and is a continuation of the report of last year on the Inundation method of sand measuring. It is presented as information.

The President:—The Chairman of the Committee recommends that the report of progress being made in methods of concrete manufacture be submitted as information. Have you anything to suggest, gentlemen?

Mr. H. C. Crowell (Pennsylvania):—One year ago I raised the question in connection with concrete specifications as to whether or not it is proper practice for the railroad company to furnish the cement when concreting is being done by contractors. I was told by the Chairman of the Committee that the subject would be given consideration during the year. I am just wondering if the Chairman of the Committee this year can tell us whether or not any consideration has been given to that subject.

Mr. C. P. Richardson:—I may answer Mr. Crowell that there was quite a lengthy discussion on this point during the year and a large number of inquiries were made to various railroads and contractors, but there was not sufficient preponderance of evidence to allow the Committee to make any suggestion at this time.

Mr. H. C. Crowell:—May we consider, then, that that subject is still in progress?

Mr. C. P. Richardson:—You may.

Mr. H. C. Crowell:—It seems to me that it is a very practical matter. The point was raised last year that perhaps it had to do with contractual relations and not to the scientific design of concrete. In our desire to get the fineness modulus, bulking factor and fifteen other varieties of refinements into these water-cement ratio specifications, of which I am generally in favor, I think we should not overlook the practical side of whether or not the cement in contract work should be furnished by the contractor or by the company. It makes a difference in the designing of the specification. For example, if it is contractor's cement you can rest assured there will be none too much of it used and there will be a tendency under the water-cement ratio specification to cut down on the water and have too dry concrete. Therefore, the necessity in that kind of specification is for an absolute *minimum* limit on slump. If it is the railroad company's cement, we do not need to worry about that feature of it; there will be plenty of cement used, and therefore plenty of water and we must fix the *maximum* slump.

It is an intensely practical matter, and I hope the Committee will continue with that angle of the subject. It will be necessary to do more than find out what is being done right now. Because railroads are generally furnishing cement for contract work is no positive evidence that that is the best method. We all know that State, municipal and Federal governments generally are requiring contractors to furnish cement. There must be some good reason for this difference.

Mr. G. H. Tinker (New York, Chicago & St. Louis):—I should like to say in that connection that we are having no trouble in designing concrete structures where the contractor furnishes the cement. The mixture and the control of the cement is entirely under the direction of the representative of the railroad company. So far we have had no complaint from any contractor. The inspector, we think, is a man of judgment and is able to put across the cement-water ratio method and to show the contractor that he can save himself money by using it.

At the present time we have a number of contracts under way in which the cement-water ratio is in use. The contractors who were at first somewhat skeptical are now thoroughly sold. Where we have ordinarily required 1-2-4 concrete, we are specifying a 2500 or 3000 lb. concrete, and we can show the contractor that he can get that grade of concrete with the use of five bags of cement per yard.

Mr. M. Hirschthal:—I just want to add our own experience in that connection. There was one time when the Delaware, Lackawanna & Western furnished the cement and permitted the contractor to furnish the labor and material and everything else. The danger of having the railroad company furnish cement, or any other single item in the construction work, is the division of responsibility. There is always a chance of the contractor coming back to the railroad and saying, "Well, that was your cement," and if any other material is furnished by the railroad company they can always come back to the railroad company and claim that the weakness

of the concrete is due to that particular material furnished by the railroad company.

On the other hand, the item of cement, as far as costs are concerned, is not such a large item. Consider the ordinary reinforced concrete structure of the expensive type that is now being installed; one bag of cement of an average value of fifty cents is only two per cent on the ordinary price of reinforced concrete structure of $20 to $25 a yard. It would not pay the contractor to take a chance to skimp on his cement and find that when the test cylinders come back his concrete shows a falling down of the strength specified.

On the Lackawanna we specify the strength with a cement-water ratio, and instructions are issued to the inspectors as to how to proceed in finding the mixture to be used for the particular aggregate then on the ground. We have found no trouble in handling the contractors that way. As a matter of fact, on the average the tests of a specimen furnished upon our contract work average higher than the strengths on our own work handled by our own B. & B. or other foremen.

Mr. H. C. Crowell:—I think Mr. Hirschthal will admit that the Lackawanna's practice and the Nickel Plate practice are decidedly not typical of railroad practice in general. I think these two companies are to be commended for proceeding along that line, even though they are in the minority.

The President:—This will be received as a progress report, and we ask that further suggestions be made.

Mr. C. P. Richardson:—Report on Subject No. 5, Specifications for Foundations, including Excavation, Cofferdams, Piling, etc., is found on page 623. The subject-matter covers typical specifications for floating caissons, pneumatic caissons and open-well dredging caissons, and is submitted as information.

The President:—Specifications for Foundations, including Excavation, Cofferdams, Piling, etc., are submitted as information. Have you any suggestions to make?

Mr. C. C. Westfall (Illinois Central):—I want to ask the Chairman to call attention to the information concerning the size of concrete mixers given in the report. It was requested that that be assigned to the Committee last year and it appears in a rather obscure place in the Bulletin. I think it should be brought up on the floor at this meeting. It appears on page 622.

Mr. C. P. Richardson:—I might state, Mr. Westfall, that the Committee collected considerable data from all available sources and tentatively considered publishing two or three pages on that subject. It was finally condensed to a small paragraph on page 622 which I might read:

"So far as your Committee has been able to ascertain, no extensive tests have been made to determine the quality of concrete manufactured under similar conditions as affected by changing the size of mixers. Results of questionnaires sent to concrete machinery manufacturers indicate that in

their investigations, the size of mixer has little or no relation to the quality of the concrete produced."

I failed to mention that small paragraph.

The President:—Have you anything further to say, Mr. Westfall?

Mr. Westfall:—That answers my point. It was brought up at last year's convention and assigned to the Committee.

The President:—Are there any further questions to be asked regarding the progress report just recently made by the Sub-Committee? If there are none, Mr. Chairman, you may proceed.

Mr. C. P. Richardson:—Progress report on Subject No. 6 on the General Practice of Waterproofing of Railway Bridges is found in Appendix E. The subject-matter consists of the tabulation of the answers to a questionnaire sent to 37 Class I railroads. I believe no comment is necessary excepting that it is very gratifying to find that the general practice of the railroads at the present time conform to the specification for waterproofing of railway bridges which was presented by Committee XV and adopted by this Association at its last meeting.

The President:—The Committee submits as progress its study and report on General Practices for Waterproofing Railway Structures, etc. Have you any questions to ask this Committee or any suggestions to make at this time? If not, the report will be received as progress.

Mr. C. P. Richardson:—Mr. Chairman, that completes the report.

The President:—This concludes the report, and Committee VIII is excused with the thanks of the Association. (Applause.)

DISCUSSION ON GRADE CROSSINGS

(For Report, see pp. 675-706)

(Vice-President G. D. Brooke in the Chair.)

Mr. Hadley Baldwin (Cleveland, Cincinnati, Chicago & St. Louis) :—Consideration of the subject-matter of the assignments to this Committee is of immediately vital importance. In all its aspects the problem is relatively unique. Generally, the ideas adopted by this Association, in its determination of recommended practice, may be made fully effective by the sole mandate of the railroads, whether individually or in associated action, and can be economically justified in behalf of the railroads alone.

In the field of this Committee's work such is not the case. The conclusions looking to procedure must take into account the statutory or regulatory limitations of public authority. Legal obligations as so established, do not always seem to square logically with the moral or economic justification of what the railroads may be required to do. So that every proposition has to be handled with regard to diverse viewpoints, diplomatically with respect to political import, scientifically with respect to an efficient and intelligent meeting of manifestly compelling needs, and economically with respect to the relation or the lack of relation between the costs arbitrarily imposed upon the carriers and the benefits which they receive.

Procedure in the field of this Committee's work will always be cramped by such conflicting influences until the public has awakened to a clearer realization of what constitutes the true economy of the situation. There must be some way to have it made clear to the people of this country that in the last analysis it is not the part of wisdom, considered solely in behalf of the general public interest, to raise all or most of the great cost of grade crossing relief and protection by the ruse of having it concealed in the cost of freight and passenger transportation.

Such expenditures of the railroads are now and will increasingly become a major item of cost such as is not reflected in any commensurable advantage in the direction of increased security, greater expedition or lessened cost of railway operation.

The solution of the pressing and distressing problems is almost wholly a matter of education in the field of sound economics. Meanwhile the situation must be met as intelligently as possible by such agencies as are available, including this Association and this Committee.

Your Committee feels that it has made some progress toward the determination of certain standards on which the railroads and the public authorities can agree, to the end that uniformity may be established where now all is more or less confusion as between the railroads themselves on the one hand and as between the laws and regulations of the various states on the other hand.

The important thing is to have our conclusions sound, making haste slowly, if necessary, to that end, having the idea that we want to be right, of course, and that this is more important than quick action. The Committee solicits, as an express request, that discussion be active and frank

with respect to the recommendations of the Committee. We seek especially constructive criticism. Questions involved in the work of this Committee are moot questions on every railroad and in every state, and the situation is one that requires the earliest possible clarification.

The first subject in order of the Committee's report, is the revision of the Manual, which will be presented to you by Mr. Maro Johnson, Chairman of the Sub-Committee.

Mr. Maro Johnson (Illinois Central):—Following the 1927 convention, the Committee on Grade Crossings was instructed by the Board of Direction to give immediate consideration to the highway crossing sign, with a view to having the plan submitted to the membership for letter-ballot, and in event of approval, to endeavor to have it adopted by the railways and specified in orders by public service bodies. Also, to consider placing on the sign an indication showing the number of tracks to be crossed, in accordance with suggestion made at the 1926 convention, and a later communication received from the President of the American Railway Association, in which was cited the practice of the Union Pacific as an example.

At the first meeting following the receipt of the above instructions, the Committee gave consideration to the design of the sign, and a plan was prepared and mailed to the membership. Replies were received from 176 members, which brought out the following comments:

Fifty-seven members approved the crossbuck sign, with auxiliary sign as designed by the Committee.

Fifty members approved the use of the auxiliary sign, but suggested changes in its details or those of the crossbuck sign.

Forty-three members opposed the use of the auxiliary sign.

Twenty-six members were noncommittal as to the use of the auxiliary sign.

Those opposed to the auxiliary sign regard it as unnecessary, liable to distract the attention of the motorist, and to lead to legal difficulties. They are for the most part men of authority on their lines and represent large mileage. The letter of a Chief Engineer of a large system is quoted as covering the views of these members. I will read the reasons given in the letter why the auxiliary sign showing the number of tracks should not be attached to the crossbuck sign:

"There is a question whether the additional sign will add anything to the safety of the motorist. The statement that there are a definite number of tracks to be crossed may lead him to be less cautious than if he is simply informed by sign that he is in dangerous territory.

"If there is no added safety to motorists there is no justification for the additional expense of maintaining the sign.

"The sign would be of questionable value unless the statement as to the number of tracks is at all times correct; it would be very easy for the proper revision of the sign to be overlooked when an additional track is added or one or more removed.

"If not maintained to show the correct number of tracks, this failure on the part of the railway would be used by damage suit attorneys as evidence of negligence on the part of the railway.

"There is an uncertainty as to whether the sign is designed to state the number of active tracks such as main tracks and switch leads, or whether it is to indicate the total number of tracks. This may be interpreted differently by different railways, adding to the confusion of the motorist.

"There are many locations where tracks of two or more railways are adjacent and a sign erected by one road would furnish information that is correct for that road's own property, but not correct considering the total number of tracks to be crossed.

"If the use of the sign is adopted by the A. R. E. A., any railway not using the sign will be placed at a disadvantage in defending suits for damages account crossing accidents."

Comment on other features of the sign as proposed by the Committee is given on page 679 Several correspondents called attention to state requirements in conflict with this sign. The Committee's instructions are that an effort is to be made to secure the adoption of such sign as is approved by the convention, by states and public regulatory bodies.

After carefully considering all suggestions received, the Committee recommends the adoption of the sign approved at the convention of 1927 with minor modifications as mentioned in its report, and omitting specific requirement for an auxiliary sign showing number of tracks at crossing, as shown on page 681 of this Bulletin.

Within the last day or two the suggestion has been made that inasmuch as the Association of State Highway Officials and also the Committee of Engineering Council on Traffic Signals have adopted yellow as the background of all caution signs, including the railroad approach and stop signs, the crossbuck sign should possibly also be painted yellow. While it may be desirable to do this for the sake of uniformity, the Committee has not had opportunity to give the matter consideration or determine just what is involved. It is not willing to recommend this change without some investigation. Presumably such a suggestion would apply equally to the frame and support of the automatic crossing signals.

The Committee would like to have an expression from the convention concerning the question of color.

In order to get it before the convention, I move that the highway crossing sign shown on page 681, Bulletin 303, be adopted as standard practice for publication in the Manual, and further consideration be given to the color of background in the Committee's assignment for next year.

Mr. H. C. Crowell (Pennsylvania) :—I wish to speak on two points in connection with this report.

First of all, the tabulation of the balloting at the bottom of page 677, and secondly, the arguments which seem to me rather specious in the typical letter on page 678.

In regard to the first matter, let me say parenthetically it seems most unfortunate that out of a membership of 2600, and presumably they were all canvassed, we received only 176 answers. Gentlemen, that is only one answer out of every 16 questionnaires sent out.

What is worse than that, the answers that came in apparently did not convince the Committee in any way because we find that out of 150 definite

answers, 107, or 71 per cent, favor the auxiliary sign, and 43, or 29 per cent, are opposed to the auxiliary sign, and yet the Committee does not make the auxiliary sign a mandatory part of the standard.

The method of weighing or equating the answers from the various members is not given by the Committee. I think it would be most interesting indeed if we could know how they weighed the answers. Possibly they were weighed on a mileage basis; if so, and assuming that three members employed by a road of 12,000 miles of line voted against the auxiliary sign, would those three members be counted as 36,000 miles?

Personally, I imagine there was no equating or weighting of the answers received by the Committee, but we are told at the top of page 678 that these 43 negative answers are for the most part from "men of authority on their lines and represent large mileage." It seems to me if 71 per cent of the members who were interested sufficiently to answer this questionnaire, are in favor of the auxiliary sign, the Committee at least should consider very carefully the answers given by those 107 members.

In the second place, as to the arguments on page 678, or rather the letter on page 678, there are really five arguments put forth here, (a) and (b), (c) and (d), (e), (f) and (g).

The first argument is that there is a question whether the additional sign will add anything to the safety of the motorists. I should like to say right here that I think it is most unfortunate that the tentative standard plan issued indicated, I believe, ten tracks. Ten tracks, gentlemen, is not a typical grade crossing in this country. We are interested in those crossings, particularly, that have one track or two tracks, possibly some have three tracks, but the great majority of highway grade crossings in this country have only one track. Second in number are those grade crossings that have only two tracks. Therefore, I say that I think it is most unfortunate that the standard indicated a sign with ten tracks.

I speak not as a railroad Engineer but as a user of the highways. It is my privilege for several weeks in the summer to tour the highways of this country, and I wish you would bear that in mind in considering my comments.

Most of us tourists over the highway are traveling in parts that are unknown to us. The man from the West travels through the East. The man from the East frequently goes to the West. The man from the West is usually confronted with the single-track grade crossing. He sees comparatively few of the double-track grade crossings. He comes to the East, and we have many double-track grade crossings. Supposing he approaches the crossing and a long freight train is on the track nearest to him. He cannot see the other track. He is used to the single-track grade crossing. There is no sign to tell him there are two tracks. When the caboose of the freight train has gone by, he does as he has done at home, proceeds across the track and is hit by a fast passenger train coming on the other track. I think, gentlemen, if the sign "Two Tracks" is put before him, that will bring to his mind at once that before crossing, after the passage of the train on the track nearest to him, he must look and listen

for the possibility of the train approaching on the other track. I think you will find, if you canvass the records, there are many fatal accidents on the grade crossings of this country due to the fact that the motorist starts out after the train has passed on the near track, and does not realize there is another track hidden from view, and that a train may be coming on that track.

Gentlemen, I say that if we can save only one-half dozen lives in the course of a year, I will say if we can save only one life by putting the sign "Two Tracks" on that crossing, it is well worth the expenditure, and I think this argument (a) and (b) is therefore not a good argument.

I will grant you it makes no difference whether there are nine tracks, ten tracks or eleven. No motorist is going to stop to count all the tracks. As I said before, there are not many of those grade crossings. We are interested in the single-track and double-track grade crossings.

We come to argument (c). "The sign will be of questionable value unless the statement as to the number of tracks is at all times correct." Gentlemen, if that had been brought up in the American Automobile Association, that the representatives of the railroad companies could not be trusted to keep their signs posted up to date, we would be the first ones to jump in and say that was all wrong. Of course we can keep the signs posted up to date. The laying of a second track is not such a common every-day occurrence that we cannot trust our Supervisors and Master Carpenters and Division Engineers to see that the proper signs are posted or changed when the second track is laid. If you get into a yard crossing of ten or twelve tracks, I grant you it makes little difference whether that change of sign is made as soon as the additional yard track is laid across, but it does make all the difference in the world when you change a single-track grade crossing to double-track.

The third argument is there is an uncertainty as to whether the sign is designed to state the number of active tracks, such as main tracks and switch leads, or whether it is to indicate the total number of tracks. This may be interpreted differently by different railroads, adding to the confusion. Can't we place on our standard plan a clear statement as to what is wanted in that respect? I think it should be the total number of tracks, but that is a matter that the Committee should consider. One thing is sure, the plan can be made definite.

The fourth argument is (f): "There are many locations where tracks of two or more railways are adjacent and a sign erected by one road would furnish information that is correct for that road's own property, but not correct considering the total number of tracks to be crossed."

Gentlemen, isn't there any co-operation among railroads? Can't two Division Engineers get together and decide what to do, and can't this Committee put on its standard plan a statement of what to do under those conditions? In my answer to the questionnaire I stated to the Chairman what I thought should be done. First of all, let us realize that the motorist does not care whether he is crossing the North and South road *and* the East and West road, or whether it is just the tracks of one road. He knows nothing

about the ownership of the tracks and cares less. He is going over a grade crossing. If the tracks of that grade crossing are so widely spaced that there is room for several automobiles between the tracks, then I submit that it becomes two separate grade crossings and should be properly signaled. Signs should be posted for the two separate grade crossings.

If, on the other hand, there is not sufficient distance between the tracks to allow several automobiles to stand after having passed one, and waiting for traffic on the other, then it becomes a single grade crossing, and it seems to me that railroads paralleling each other could very easily take care of that situation; all of which should be outlined on the plan.

The last argument is, "If the use of the sign is adopted by the A.R.E.A. any railway not using the sign will be placed at a disadvantage in defending suits for damages." Gentlemen, that could be brought up just as well in connection with many, many things we do. If it is the right thing to state there is a double-track crossing and not a single-track crossing, if it is the consensus of opinion that that is the right and safe thing to do, for goodness sake let's do it, and not pass the buck and say that somebody might get into trouble because he does not go along with the A.R.E.A. standard. Make him go along with the A.R.E.A. standard. Let's set the pace in this crossing sign design, and the American Automobile Association will undoubtedly follow us, and it will become general throughout the states. Let's not leave it optional as it is on the plan. (The Committee might have gone even further and dotted all the lines on the plan leaving the whole thing optional.) Let's be definite.

Mr. Maro Johnson:—I am sorry I have not here the letters that came in on this proposition. There are two schools of thought and both sides are very decided that their view is correct. The Committee in considering the replies felt that the 43 men who voted against the proposition carried more weight, and certainly represented very much more mileage than the 107 men who voted to place the sign on the post.

Mr. C. W. Baldridge (Santa Fe):—As I remember the letter which was sent out asking an immediate vote on this matter, it was a letter from Mr. Aishton, the President of the American Railway Association, in which he pointed out that a certain state was considering passing laws in regard to crossing signs, and they were considering the passing a law compelling the roads to show the number of tracks to be crossed and Mr. Aishton in his letter, as I remember it (and if I am wrong, I hope somebody will quote his letter correctly) wanted an expression of this Association last summer on this subject, so that he could use it, that was what brought about the sending out of the letter-ballot to the membership.

In regard to the reasons given in this typical letter as Mr. Crowell has cited, in (a) and (b) are given statements that the signs might not be kept up to date, and that there was a question whether they were needed or not.

I contend that a board on a crossing sign showing the number of tracks to be crossed gives definite information to the driver which he is entitled to. At the bottom in the last paragraph of this typical letter they

quote the gentleman who wrote it as saying he preferred to put a board on the posts which read "danger."

The decision in the United States Supreme Court, put out within the last year, very definitely stated that any person with sufficient intelligence to drive an automobile must know that a crossing of a railroad track is a place of danger. Consequently, a word on the sign post reading "danger" does not give him any information that he does not already have. A board showing the number of tracks to be crossed does give him information which he may not have.

Mr. Chairman, I am going to offer an amendment to the motion before the house to read as follows: "That the design for crossing sign as shown on page 681, Bulletin 303, be amended by the addition of a board to be placed immediately below the state law board as shown, on which shall be shown the number of tracks to be crossed," and that the plan so amended be adopted for inclusion in the Manual.

Mr. H. C. Crowell:—Mr. Chairman, I should like the privilege of seconding that motion.

Mr. A. H. Rudd (Pennsylvania):—I was very much interested this morning in reading the report handed around as to the organization of this Association. Its membership is composed of private individuals and not of appointed representatives from the various railways. Membership is entirely voluntary and those who join the Association do so because of their interest in the work it is doing.

Is seems to me, therefore, the mileage of any individual membership should be limited to six feet.

The Sub-Committee of Committee X collaborated with this Committee right after the meeting yesterday. We have explained how we had collaborated previously. I talked to Mr. Johnson and Mr. Batchellor on the approach sign which is one that our Committee has been especially concerned with. Unfortunately, I did not bring the data with me so I must quote from a memory which is very treacherous. I can not state just exactly, but there is one state which requires this board about which we are talking to show the number of railroads crossed, not the number of tracks, but the number of railroads.

The approach sign in Virginia has two horizontal stripes for railroads regardless of the number of tracks. The A.R.A. sign is one stripe.

If we put this sign up voluntarily you can see what is going to happen. In one place it will mean two railroads by law, in another place it will mean two tracks by something else. The Supreme Court decision said that if a man entered on a railroad track or tracks (it is immaterial), he knew that he was in a dangerous place and that if he did not get off that railroad before the train came he was liable to be killed because the train would not stop and he should stop.

I have a tremendous sympathy for you poor Western men, single-track railroads, who come East and get onto one of our great double-track trunk lines and get killed because you do not know they are double tracks. The most people killed on these double tracks come from the East, however,

and perhaps it is a wise dispensation of Providence that some of them are taken care of in that way, because if we do not get them they will get somebody else further up the road.

It seems to me our duty ceases, first, when we indicate by an approach sign that we can get somebody else to put up that the driver is approaching a railroad; second, showing where the railroad is; and third, if the crossing is so bad that he can not see the trains to give him an indication that there is a train approaching and if he does not know, if he can not see there is more than one track there, day or night, it is either because his eyesight is so bad that he should not be allowed to drive or that his headlights do not conform with the law.

Mr. H. C. Crowell:—I have no desire to compete with Mr. Rudd as a humorist, but I fear he is one of the theoretical tourists while I am a practical tourist and have had practical experience, and I think that my eyesight is pretty fair.

Mr. A. H. Rudd:—I am fairly practical myself. I have driven a car for twelve years and have never had an accident at a grade crossing. What I do is stop when I come to a crossing whether I am told to go ahead or not. I stop, look and listen, and if you will do that you will not get caught no matter how many tracks you have.

Mr. V. R. Walling (Chicago & Western Indiana) :— It seems to me the reasons given in the letter on page 678 are in general very good.

I wish to call particular attention to item (d) which is of special importance; "If not maintained to show the correct number of tracks this failure on the part of the railway would be used by damage suit attorneys as evidence of negligence on the part of the railway."

I think if we were to present that matter to our respective law departments they would say that such would be the case, and regardless of the fact that the signs if put up should be properly maintained, as a practical matter they are not always so maintained and there would be possibilities of law suits that might be very serious.

Mr. C. W. Baldridge:—The second speaker before me commented on the fact that certain states have passed laws regarding use of stripes to show the number of railroads to be crossed and not the number of tracks.

There is another state, if I am not mistaken, that has passed laws requiring the signboards to show the number of tracks to be crossed, which is exactly in line with Mr. Aishton's letter, that he wished this Association to establish something that would enable the A.R.A. to go before the legislative bodies and urge uniformity of signs.

So far as practical results are concerned I do not believe it will matter in three or four years from now whether we adopt a sign which provides for showing the number of tracks or not, the laws will do it for us, and if we do not want them to be different in different states, it is up to us to take action now.

Mr. E. R. Cotton (Chairman of the Steam Railroad Section, National Safety Council) :—This little information I am about to give you might be of some help at arriving at your decision and it is this: That the statis-

tics of the various railroads on grade crossing accidents indicate this one fact, that in from 78 to 89 per cent of grade crossing accidents the driver of the car lives within five miles of the grade crossing, which might indicate his familiarity with the crossing and the number of tracks. There are reliable statistics that 2 per cent or less of grade crossing accidents occurring on the larger lines occur through tourists who are unfamiliar with the country.

Vice-President G. D. Brooke:—This is a very important subject, gentlemen. Is there any further discussion?

Mr. Meyer Hirschthal (Delaware Lackawanna & Western):—It seems to me the object in the crossing sign is to acquaint the driver with the fact that there is a crossing, it might be single or double track, and with the object in view of having him "slow up." It makes no difference how many tracks there are, provided he does slow up, and nothing but a slowing up will get him safely across the tracks.

Mr. W. H. Woodbury (Duluth & Iron Range):—I want to call attention to the unreliability of the statistics. The gentleman just remarked that many more accidents occur to people who live in the neighborhood. That means that there will probably be ten or fifteen times the number of crossings by those people than by tourists living further away, so I do not see where the statistics he quotes have any bearing on this subject at all.

Vice-President G. D. Brooke:—Gentlemen, there is an amendment to the motion before you to modify the proposed crossing sign standard as shown on page 681. Is there any further discussion?

Mr. Hadley Baldwin:—Mr. Chairman, I should like to say just a word or two about the attitude of the Committee in respect to this point, and in respect to this recommendation at large.

At a previous convention two years ago, I believe it was (I was not with the Committee then), a standard highway crossing sign was adopted. It was very similar in all its essential features to this which is now proposed. This year's Committee was requested through the Board of Direction to prepare a design with a board indicating the number of tracks to be crossed. The Committee this year, which had been somewhat reorganized, was not unfriendly to that proposition and prepared such a design which was submitted as stated, but the Committee did not feel that in view of the diverse response and the small percentage of response, and in view of the very positive attitude of members of this Association to using this particular feature, that it would be justified in recommending it for adoption. It is a matter that should have very careful and exhaustive consideration of the members. It is in that spirit that the matter has been submitted at this time with respect to that particular feature. Mention was made of the signboard indicating ten tracks. That may have been misleading in some respects, but it was not with the idea of indicating that as a typical situation. It was simply to show the size of the board where required for more than nine tracks.

This would be desirable so that when the plan for the desired sign went to the builders or the makers, they would have the dimensions to go on and the Association would understand why the plan was made to that size.

If this Association adopts this design or any design, as I understand it, it is still, as I stated in my opening remarks, up against the question of whether or not the states or any of them will authorize its use. This is recommended practice, and as such the railroads are not in a position at their own mandate to put it in use. This plan, as I understand it, is something the railroads will agree upon, and on the basis of which we can secure agreement among all the states, possibly, and have one uniform indication throughout the whole country. The adoption of this design or any design by this Association does not put in into effect, and it will not authorize the railroads to put it into effect.

I am very much interested in the discussion, and I feel it is very constructive and valuable and is just what the Committee wanted.

Mr. W. E. Hawley (Duluth, Missabe & Northern) :—I have been considering the discussion that has been going on on this motion before the house, to add the sign which will indicate the number of tracks at the crossing concerned. I feel that it would be a mistake for this Association to put such a recommendation definitely in the report because with those states and those railroads which do not choose to follow that, in case of an accident, it will be used against them in court as a failure to follow a recommendation of this Association, which undoubtedly will be explained to the court, and make it appear bad against the road. A road in a state might have some good reason, or the laws might not provide for it, for leaving the sign off the post showing the two tracks or more.

Mr. J. M. Farrin (Illinois Central) :—I drive a car once in a while myself, and in driving around I have taken particular pains to notice how the different motorists approach a railroad crossing. I have seen many cars with a sign stuck on the back, "This car stops at all railroad crossings," and I have seen many of those cars cross many a crossing without stopping.

People here in Chicago remember that not very long ago there was quite an unfortunate grade crossing accident in one of the suburbs in which a line of cars was stopped waiting for a train to pass. Back of that line of cars a lady drove up in her car with four people in it. She stopped and then deliberately turned out of the line of cars and drove across the track and as I remember now all four of them were killed.

When people do such things as that, I can not see what is the use of putting a sign up stating that there are a certain number of tracks. If the railroad companies call attention to the fact that you are approaching a railroad track, I think the number of tracks has not anything to do with it at all. The man who will cross one track without looking will cross ten, or any other number. If he does it, my contention is that he does it at his own risk and on his own responsibility.

Mr. W. L. Roller (Hocking Valley) :—It may be that the information will be disregraded by the major number of motorists, as has been stated here that the motorists will not observe the information given.

Many instances are on record where accidents have occurred due to the fact that this information was not given, and I think the railroad that fails to give the information to the motorist is peculiarly responsible.

I recall an accident which resulted in the death of Governor Hanley of Indiana where that information was not supplied, and where it was found the information was not known to the driver of the car that it was a double track. His car passed back of a freight train and was struck by a train on the opposing track.

Mr. H. C. Crowell:—It is just such an accident as that that I had in mind. I think Mr. Roller has explained it perfectly, and the small amount of money involved in putting up this additional information is little compared with the value of human life.

Vice-President G. D. Brooke:—Are you ready for the question on the amendment?

Mr. V. R. Walling:—In Mr. Crowell's able presentation of his side of the case, it seems to me what he feared mostly was this matter of automobilists crossing double tracks, not where there were a number of tracks.

Before the amendment is voted on, I wonder if Mr. Baldridge would consider changing the amendment which applies to the sign for a single track to read, "Single Track Only," and for crossings of more than one track indicate "More than One Track." This will get away from the point of definitely naming the number of tracks which, according to Mr. Crowell, he did not consider important.

Mr. C. W. Baldridge:—I accept that change in the amendment.

Mr. H. C. Crowell:—As the seconder of that amendment, I will accept it also.

Vice-President G. D. Brooke:—The change in the amendment which has been accepted is that there be placed on the sign below the stop and state law sign, indicated in dotted lines as being optional, an additional board showing for single track the words "Single Track," and where there is more than one track the words "More than One Track." Is that correct?

Mr. G. H. Tinker (New York, Chicago & St. Louis):—I think that sign would be more effective if the first one were omitted entirely. If there is to be any additional board at all indicating the number of tracks, there should be but one board saying simply, "More than one track."

Mr. H. C. Crowell:—I think Mr. Tinker's suggestion is very good. I hope Mr. Baldridge will accept that.

Mr. C. W. Baldridge:—What I had in mind was simply a notice to drivers that there was more than one track to be crossed, and that is really important. Since one of the speakers mentioned an accident which occurred here in Chicago where four people were killed, after the driver deliberately drove out of a line of cars that went across the track, I will remind you of a circumstance that happened on the western edge of Chicago several years ago where a funeral car drove behind a freight car onto the second track, innocent of any carlessness, and nine people lost

their lives in that accident. That was due to double track, and a board put up there will sometimes jog the memory of a person who *does know* there is a double track. It might serve as a reminder.

(The question was called for and the motion was lost.)

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis) :—I should like to ask whether the last amendment was accepted or not, and if the last suggestion was on the amendment to leave off any notice that a single track was there, but place it where there was more than one track. I do not believe the convention was quite sure of exactly what they voted on. I know I was not and did not vote.

Vice-President G. D. Brooke:—The vote was on the second accepted amendment, to leave off any additional information where there is one track, and where there is more than one track to add the information "more than one track."

Mr. Hunter McDonald:—I presume all the members understood that that is the amendment they voted on.

Vice-President G. D. Brooke:—The vote was close, as I see it, and I will ask those in favor of the motion to rise. Will those not in favor of the motion arise?

(The amendment was lost.)

Mr. W. L. R. Haines (Pennsylvania) :—In view of the very inadequate response that was made to the questionnaire sent out by the Committee in regard to the acceptance or rejection of this crossing sign, it seems to me that it would be very unwise for this convention to adopt this crossing sign as recommended practice. I think the whole matter should be reassigned to the Committee with instructions that they attempt to secure a more definite expression of approval or disapproval from the members of the Association.

Unless there is a motion before the house, I will move that this reassignment be made.

Vice-President G. D. Brooke:—There is a motion before the house on the adoption of this sign.

Mr. H. C. Crowell:—In view of the fact that the Committee itself was about equally divided and that only a small portion of our membership are here this morning to vote on this subject and so few voted on the letter-ballot, I should like to make an amendment to the motion before the house that the whole matter be referred back to the Committee for further study this year. If Mr. Haines wants to second that amendment, here is a chance to get a vote on that.

(Mr. Haines seconded the amendment).

Mr. W. E. Hawley:—I should like to add that it would be well if the Committee could work in collaboration with the Safety Section and others interested in this so when the report comes back next year it may be a greater expression of unanimity of opinion as to what is best in practice.

Mr. T. E. Rust (Waterloo, Cedar Falls & Northern) :—I do not believe the Committee is divided at all on this question. I had not quite

grasped what we were voting on. I thought we were voting on whether or not we left off that board showing number of tracks, and not on the amendment in general.

Mr. H. C. Crowell:—The vote was divided.

Vice-President G. D. Brooke:—The amendment is before you. Is there discussion? If not, those in favor will please say "aye," contrary "no."

(An explanation of the amendment was called for.)

Vice-President G. D. Brooke:—Mr. Crowell, will you state the amendment to the motion?

Mr. H. C. Crowell:—The amendment to the motion is that in view of the fact that the Association as represented here seems to be pretty evenly divided on this matter of indicating more than one track at a railroad grade crossing, and in view of the fact that only one member out of sixteen voted on this matter by letter-ballot, and in view, further, of all the discussion that we have had this morning it seems to me wise that the Committee take the matter under consideration again, conferring with the American Automobile Association and other associations who are interested in this proposition.

Mr. W, M. Post (Pennsylvania):—I think it might be well for the Committee to state whether there would be any useful purpose served by having it referred back to the Committee. I anticipate that if another letter-ballot is sent out they will get about the same response from just about the same percentage of the membership. If the Committee is now agreed as to what should be done, I doubt very much whether there would be any different report brought in next year. It will postpone the whole matter for a year at least.

Vice-President G. D. Brooke:—Are you ready for the question? Those in favor of the amendment will please rise; contrary-minded, please rise. The amendment is carried.

Mr. G. H. Tinker:—May I suggest to the Committee that in their consideration of this subject they seriously consider the question of the colors. I can not quite quote the authority, but I am quite sure it has been very well established that a combination of yellow and blue has much greater visibility at night than black and white. Anyone can verify that for himself by noting the license plates on automobiles from those states which have that combination of colors.

Mr. C. C. Cook (Baltimore & Ohio):—May I not inquire if we do not now have a crossing sign standard previously adopted by this Association, which is essentially the same as the one here recommended?

Mr. T. E. Rust:—Yes, and that was adopted again last year.

Mr. A. H. Rudd:—Then it seems to me all right to defer the third adoption until next year.

Mr. Hadley Baldwin:—Subject No. 2, Methods for apportioning the cost of highway improvements adjacent to railway right-of-way, (a) Within incorporated limits of municipalities; (b) Without incorporated limits of municipalities, will be presented by Mr. Bernard Blum, the Chairman.

A

Mr. Bernard Blum (Northern Pacific) :—The report on this subject is shown on page 682 of Bulletin 303, Part 1. The assignment for this Sub-Committee last year was the same subject confined to highways outside of incorporated municipalities. This year the work has been confined to improvements within such limits. In order to ascertain what the practice was throughout the country, inquiry was made of the practice in various cities and states from the chief tax officers of fourteen large railways. The questions submitted are numbered 1 to 6 on page 682.

In order to report briefly, your Committee has summarized the replies to each question, which are given on pages 683 and 684 of the Bulletin. The results of this questionnaire indicate that, in general, communities treat the railways quite fairly, and although, of course, many problems arise which the tax officers have to take care of individually, there would not seem to your Committee to be a problem sufficiently great to warrant further activities along these lines. We recommend that further study be discontinued.

Vice-President G. D. Brooke:—Appendix B is offered as information and will be so received.

Mr. Hadley Baldwin:—Subject No. 3 and Subject No. 7 are so related that we assigned to one Sub-Committee the two subjects. The first subject is Comparative merits of various types of grade crossing protection, collaborating with Committee X—Signals and Interlocking, and the other is Various types and locations of approach and warning signals for grade crossings, also the practices in the several states and federal requirements, with a view to securing uniformity of practice and standards.

Mr. F. D. Batchellor, Chairman of the Sub-Committee, will present the report.

Mr. F. D. Batchellor (Baltimore & Ohio) :—This report starts on page 685. There has been considerable said at the meeting regarding Committee IX collaborating with Committee X. As I read our assignment No. 3, we are to collaborate with Committee X. As I see the assignment of Committee X, they were to collaborate with Committee IX.

Unfortunately, our report was not gotten out at an early period, but we did send that report to Committee X. However, we never received a report from Committee X of the report which they had made. It seems to me that these two subjects are so closely allied, that probably the two Sub-Committees should meet together, and we will be very glad to do that, if the same subjects are on next year.

We tried to determine, by getting statistics, just what progress had been made in eliminating railroad crossing accidents, and also determine what type of crossing was the most effective.

During the year 1926 there were added to the already existing railroad crossings 1457, in spite of the fact that a large number were eliminated.

The statement on page 685 shows the different types of protection, and it will be noted from this statement that there were 216 less crossings protected by gates, 170 less crossings protected by watchmen, while the crossings protected by signals increased 1028.

On page 687 we have compared the number of accidents at crossings in 1925 and 1926, and it will be noted that there was an increase in 1926 of 410 accidents, or 7½ per cent. In the next statement we have tried to show what kind of vehicle was having the most accidents at the different crossings, and it will be noted that the motor propelled vehicles are far in advance of the other types, in fact, they are practically the only ones which show an increase.

There was an increase in motor registration 1925 over 1926 of 2,092,-600, or an increase of 10 per cent. If we take the registration and the number of accidents in these two years, we find that in 1925 there was one accident for every 3660 machines, while in 1926 there was one accident for 3761, which would indicate, in spite of the fact there are more crossings and more machines, that we made a little better showing than we did the year before.

At the bottom of the page we have taken up the type of protection which we recommend. Fig 1 shows the type of flashlight or wigwag signal, and Fig. 2 shows the location. We desire to eliminate from the report under Fig. 2 the words, "Where practicable they should be placed in the center of the highway." We further want to withdraw our recommendation that this be adopted for the Manual, as we have found that there are some slight discrepancies between the signal which we have shown and that adopted by the Signal Section, and we would recommend that this be referred back for further consideration.

With regard to the approach signs, we have shown a table showing how these are used, and it will be noted that in 37 states they are using the U. S. standard highway sign, or that adopted by the American Association of Highway Officials.

We recommend that we approve the signs adopted by the highway officials. These are shown on page 692, and I would call attention to those who have been discussing regarding an additional sign on the crossing post that in this caution sign there is provided two lines to show multiple crossings. I might state that this sign, while it does not conform exactly to the A.R.E.A. standard or the A.R.A., practically has been adapted from that. The difference is in the size of the letters and in the border around the circle.

I move the approval of the caution signs by the Association.

Mr. R. H. Ford (Chicago, Rock Island & Pacific) :—I am not clear as to what the approval means. My understanding is that these signs have been adopted by the Association of Highway Commissioners or Engineers, I have forgotten which, and they represent their views on them. I can readily see why the Committee take the position that they do, and I think it is in line with uniformity. It should be so reported.

On the other hand, these are essentially signs that pertain particularly to the highway crossings on railroads, and my review in a study of those signs would rather indicate that when they were proposed, very little study was given to them. In other words, they just happened. Now they have been carried along because of the great desire, and with which I am in

thorough sympathy, for uniformity and standardization. I do not think the highway commissioners, with all due regard to them, are in any position, by training or experience, to design or pass upon signs for railroads. I think that is peculiarly and particularly within the province of this Committee, and I should like to suggest that the Committee merely present them as information without comment either for or against them. My reason for that is I am confident that if they will study them further, in the light of railroad necessities, they may perhaps want to modify that somewhat, and perhaps will be in a position to work constructively with the highway people for their modification. I want to say in passing, also, that there is a feeling on the part of a number of thoughtful men among highway authorities that these signs are not all that they ought to be. With that feeling on their part, and a very strong feeling that some of us have with respect to the other part, I trust that the Committee will merely present them as information, without recommending either for or against.

Mr. V. R. Walling:—I note on page 685, under kind of protection, it is shown that number of gates have decreased in 1926 as compared with 1925, with an increase in the use of fixed signals.

At the top of page 687, I believe if the Committee had carried out some percentages in that table it would aid in making comparisons. I have just roughly drawn off some percentages, and it would appear that in 1926 over 1925 there was an increase of about 8 per cent in the number of accidents, divided, 8 per cent for gates, and 14 per cent for signals. Under persons killed, with gates there is a decrease of 13 per cent, while for signals there is an increase of 20 per cent.

Mr. A. H. Rudd:—In regard to the signs on page 692, I think it was 15 or 20 years ago that the American Railway Association adopted the approach sign as we know it, with the cross, the letters "R.R." in 5-inch letters, and the white background.

I think it is unfortunate that they did adopt that particular sign in view of later developments. Massachusetts and three or four other states show a cross for an intersecting highway. It is like ours without the "R.R." It is the natural sign to show. They show a straight line with a line coming in from the right if there is a highway coming from the right, a straight vertical line with a line to the left if there is a highway coming in from the left. If this sign had been made in the form of a cross similar to the crossbuck sign in the first place, it would have been very distinctive. However, there are thousands and thousands of them in use.

If we make any change in these signs, if this Association makes any change in those signs, it should be reported to the American Railway Association as the action of a section of that Association in order that the Board of Directors of the American Railway Association may approve it. Otherwise, we will not get anywhere.

As to the stop sign as recommended, that has been adopted by the National Association of Highway Officials. It has been put up to the Hoover Conference. It has been considered by the Committee on Code on

Traffic Signals and the American Engineering Council is recommending that on the stop sign the letters be red instead of black.

It seems to me that we use the stop sign only in a few states; for instance, in Illinois in extra hazardous crossings. We have, I think, a red circle now that works out well, and this stop sign could be very well referred back to the Committee for another year, because the American Engineering Council will report within a month or two and the National Safety Conference is expected to convene again in the late spring or early summer to pass on the proposition of stop and crossing signs.

The sign with the double bar on it is, I think, shown by mistake. The first literature of the highway people showed that. I was in correspondence with them and if I remember correctly, they told me that was an error.

As I said yesterday, the state of Virginia requires those two horizontal bars for a crossing whether it is multiple track or single track. The Committee recommends that the remaining sign, the one with the cross and "R.R.," be adopted, showing 6-inch letters as against 5-inch which we now use, and the yellow background.

I believe we ought to recommend it, for the reason that there is not any question that the National Conference is going to adopt the principle set forth by the Association of Highway Officials, that all caution signs shall be yellow background with black letters. When we paint all the existing signs, we will paint the white background yellow, if we have to maintain them, and in new signs we can just as well go to the 6-inch letter as the 5-inch.

These signs are erected by the local officials. They are on the state highway or county roads and off our right-of-way, and we have no right to erect them. In that way they do have something to say about the sign we use. I think we either ought to adopt it or refer the whole matter back. It may not be too late for this Committee to take up with the Highway Officials (forty-six states, I think, have commissions) the matter of changing your approach sign, if it is thought advisable to do it, and make it a cross, but it seems to me it is one of those things that is pretty late to straighten out.

Mr. Robert H. Ford (Rock Island):—While appreciating the good work being done by this Committee with respect to this matter on signs, I am confident that a further and somewhat independent study is very desirable, and for this reason, I move that the matter be referred back to the Committee.

Mr. A. H. Rudd:—Mr. Chairman, in seconding that motion, I should like to say one more word. By another year I believe this question will be settled as far as the National Conference is concerned and as far as the Highway Officials are concerned. Meanwhile it would give the Committee a chance to agree with them if they want any changes. They have adopted our sign, not because they thought it was the best, but because there were so many of them and the railroads were recommending them. We ought to meet them more than half way.

Vice-President G. D. Brooke:—Is there any other discussion?

Mr. Hadley Baldwin:—I think it is well understood that these signs are primarily state highway department signs. They are not railroad standards, and the idea of this Committee was that it was a courtesy, if you please, perhaps nothing more than that, to recognize the standard published by the State Highway Association in view of the fact that railroads have a secondary interest in the matter and are sometimes required to install and pay the expense of upkeeping these signs. The aspect of the matter is that unless the public authorities require the railroads to install some sign that imposes an unreasonable cost on the railroad company, it is something entirely within the jurisdiction of the state highway authorities.

The expectation of the Committee was that this Association would say to the state highway officials in effect, "You have adopted these signs, and we approve." We can acquiesce in the use of the signs without any further question. Then if the question comes up in any state or any railroad, there will be no question about the detail of the sign. That is about as far as we can go in the matter.

However, if we were to express our approval at this time and the State Highway Association later changed their standards it would be strictly in order, and it would be a very simple matter, for this Association to follow along unless it should see something it would feel justified in taking exception to.

The Committee does not object to having the matter referred back, but it seemed to us that it is entirely consistent to take the action we propose at this time and the future would take care of itself very naturally and simply.

Vice-President G. D. Brooke:—You have heard the motion. Those in favor say "aye;" opposed "no."

(The motion was carried).

Mr. Hadley Baldwin:—The subject of the next assignment is Study of excessive number of highway grade crossings of railways, with methods for their removal. This report will be presented by Mr. L. J. Riegler, Chairman of the Sub-Committee.

Mr. L. J. Riegler (Pennsylvania):—This report on excessive number of highway grade crossings of railroads, with methods for their removal, is published in Bulletin 303 on page 694 as Appendix D.

The burden of the report, briefly, is the conclusion that grade separation, used in the narrow sense, meaning the construction of an underpass or overpass to achieve the elimination of a grade crossing, as has heretofore been depended upon is inadequate and by itself is not practical, nor conducive to early results. Although great sums of money have been expended for grade separation projects, hardly any impression has been made upon the grade crossing problem. The extraordinary expense attending grade separation has retarded elimination. In fact, the cost is so great as to discourage not only the railroads but the public authorities in such undertakings.

To solve the problem adequately, some method must be found that will eliminate a large number of existing grade crossings at negligible ex-

pense as compared to grade separation. Such a plan would comprise two propositions; first, the restriction of new grade crossings; and second, the elimination of existing grade crossings. The latter would be divided into three proceedings: first, the vacation and closing of crossings; second, the diversion and relocation of highways to avoid crossings or perhaps in some cases the relocation of the railroad tracks, and, third, grade separation.

Heretofore, the initiative in grade crossing elimination has generally been with the public authorities, as because of the great cost and inequitable distribution of the cost, the railroads have more or less been on the defensive. Public authorities can be relied upon to bring up the question of elimination on important highways where grade separation is required but for highways of lesser importance, and equally dangerous from the railroad standpoint, it is our opinion that railroad companies should take the initiative.

The report is presented for the purpose of having it accepted and the recommendations contained therein referred to the Board of Direction. The recommendations are on page 699.

(President D. J. Brumley in the Chair.)

The President:—You have heard the report on restriction of new grade crossings, elimination of existing grade crossings, diversion and relocation of highways, and grade separation, and the recommendations referred to by the Chairman of the Sub-Committee.

Have you any suggestions to offer or any criticisms to make?

Mr. S. T. Wagner (Reading):—It seems to me that the matter contained in this report is of unusual interest. It has in it and through it a large number of points that I do not ever remember having seen in print before on this general subject of grade crossings. If anybody has not read it and is interested in grade crossings, I think he should do so.

My attention was first attracted to it by the statement at the bottom of page 696 in reference to the cost of grade separation, which the Chairman of the Sub-Committee has referred to.

About eight years ago I attended in this city a conference called by the National Association of Public Utilities Commissioners at which there were a large number of representative bodies interested in the safety of the public. It was brought about by the first violent effort made by automobiles to destroy themselves at railroad grade crossings. During that discussion, a representative of the State Highway Department of Wisconsin got on his feet and upbraided the railroads on account of their lack of interest in the removal of grade crossings, which he said could be accomplished for $15,000 apiece, and it was a shame that they were not doing more than they were. The figure of $15,000 interested me much. As soon as I had a chance to get on my feet, I called attention to the fact that that year I had especially investigated the cost of removal of grade crossings in the state of Pennsylvania and had found that they averaged about $75,000, big and small. I was convinced that even at that time $75,000 was too low a figure for an average. I referred to the fact that the Pennsylvania Railroad, before the war, issued some propaganda in connection with the

removal of grade crossings in which they showed the total cost of the removal of all the grade crossings on the Pennsylvania Railroad System, and they based their estimate at $50,000 per grade crossing.

I called attention to this figure in this discussion. I had hardly sat down before a representative of the New York Central got up and accused me of being entirely too low in my average figure, that I should use at least $120,000 or $125,000 for an average. He had hardly finished before the Chairman of the Pennsylvania State Commission got on his feet and referred to an individual project of the state where three grade crossings had been eliminated at a total cost of something over $3,000,000, an average of approximately $1,000,000 each.

On our system we made plans for the removal in a municipality in Eastern Pennsylvania of three street grade crossings and an alley. The estimated cost was $4,500,000. When the municipality found they would probably have to pay half of the cost, they were not so interested, and the project fell dead. Since that time I have noticed figures given in the Railway Age showing the cost of removal of grade crossings in the state of New York under the New York state law. The gross costs of those crossings are given, as I remember the figures, in the first lot[1] running up to $172,300 for crossings and in the second lot[2] running over $256,000 a crossing. The argument of cost is a tremendous one, and therefore all that the Committee has suggested, and (without going into detail and referring to them in a large number of places,) all the methods by which these grade crossings can be done away with before they come to be a serious menace, is a well worthwhile program. Even in states like the state of New Jersey, for instance, where at the present time practically the whole cost devolves upon the railroad companies, it is possible for the railroads to get in touch with the local authorities and, if they can, agree with them on a cost for the elimination of crossings which is a fair one to both sides.

Mr. Robert H. Ford (Rock Island) :—This subject is so important that I trust the convention will bear with me for rising again to speak upon the report.

The Committee are to be congratulated upon the excellence of their recommendations. They might, however, have gone further in the matter of the creation of additional grade crossings.

For years, it was the custom of the railways to quite freely acquiesce in establishing additional crossings over their tracks but the march of events has necessarily changed this practice, because it has now become recognized that every additional grade crossing is also creating an additional hazard to the public as well as the railroads, and becomes a potential grade separation for the future.

It is a serious reflection upon public authorities charged with the responsibility of such matters, that even with the staggering amounts that have been paid for grade separations, yet according to the last report of

[1] Railway Age, Feb. 6, 1926.
[2] Railway Age, Dec. 8, 1927.

the Interstate Commerce Commission, there was a net increase of 1525 grade crossings over the tracks of the American railways during the past year.

Local interests and private greed, coupled with poor engineering, are the fruitful causes for most of these increases. Of the two hundred and fifty odd thousand grade crossings in existence today, fully 75,000 could be combined or closed entirely by judicious relocation and a more liberal use of the Federal-State highway system.

The power of State Railway Commissions should be invoked to prevent these indiscriminate increases, and the management of some of the railroads, notably the Rock Island, have finally determined that as a matter of public policy, they will not longer assume the responsibility of agreeing to the creation of these additional hazards without a positive order from the Railway Commission of the respective state in which the proposed crossing is demanded.

It is to be hoped that the Committee will study this problem from the broader aspect of the public as well as the railroads, to the end that State Railway Commissions will join with the railways in requiring that the practice be stopped, or at least minimized to the greatest possible degree. In some states the laws do not permit of the creation of these additional hazards under any circumstances.

The President:—Are there any further suggestions?

Mr. F. C. Shepherd (Boston & Maine):—I should like to speak along the line of bringing to the attention of the railroad authorities the study of doing away with crossings by closings or by building side line roads. It is rather interesting that in connection with the New York State law we have about a hundred grade crossings. I made rough studies a year and a half ago and presented them to the Commission or to their engineers by which we suggested some thirty crossings could either be closed because they were not important, or could be closed by short sideline roads, and we have already succeeded this year in having three crossings closed by side-line roads, costing a little over $3500. The railroads pay one half and the state pays the other part. There is quite a field in that line.

The President:—Anything further, gentlemen? If there is not, the recommendations of the Committee will be taken under consideration by the Board of Direction.

Mr. Hadley Baldwin:—The next subject in this report is Item No. 8, Study and report on (a) Laws and regulations affecting the apportionment of federal aid; (b) The proper form and character of division of costs of separation of grades as between the railway, state, county, municipal or other corporation. Report will be presented by Mr. Frank Ringer, Chairman of the Sub-Committee.

Mr. Frank Ringer (Missouri-Kansas-Texas Lines):—The report of the Sub-Committee is printed on page 700 and continues through page 704.

The first portion of the report gives a summary of the provisions of the Federal Highway Act as given on pages 700 and 701, and at the top of page 702.

"The Sub-Committee understands that the present practice, under the rulings of the Bureau of Public Roads, is that Federal aid may be allotted

to construction of railway grade crossing separations to the extent of 50 per centum of the cost thereof, except that the Federal authority has declined to reimburse the state for more than the amount actually paid by the state.

"Under the provision of the Federal aid act a definite allotment of funds is made to each state, which is the maximum of Federal aid which it may receive from the amount appropriated. It follows, therefore, that if Federal aid is not used for paying any part of a railway grade separation, the state has an accordingly greater amount left for use on other road improvements. There is a tendency on the part of some states to apply Federal aid in this manner, and as a result fewer grade crossings are eliminated than would otherwise be done.

"It is understood there is no provision of the Federal aid act which railway companies can use to compel the states, through legal proceedings, to apportion part of the Federal aid allotment to a particular grade separation project, and it is possible for necessary grade separations to be segregated and kept out of Federal aid projects.

"It is understood that classification of railway grade crossings of Federal aid highways has not yet been completed. It is the view of the Sub-Committee that a statement showing by states classification of railway grade crossings of highways of the Federal aid system should be prepared and published annually by the Bureau of Public Roads."

On pages 703 and at the top of 704 is compiled information secured from the roads showing provisions of states governing division of costs of highway grade crossing eliminations. That is summarized on page 704. Of the 48 states, the division of costs is determined by the state commissions in 24 states, by special statutes in 13 states and by agreement or through court processes in 11 states.

As to the second part of the assignment, "Proper form and character of division of costs of separation of railway grade crossings;" a questionnaire was sent out to the roads requesting information as to the cost, separated between the apportionment paid by the railway, the state or other municipal authority, and Federal aid, for different classes of crossings, following the classification which has been outlined by the Bureau of Public Roads.

The information furnished in reply to that questionnaire is summarized on pages 705 and 706. Some 101,000 miles of roads reported costs of grade separations, and only a small proportion reported no costs. 70,000 miles of road reported or answered the questionnaire reporting a segregation of costs borne by Federal aid. Summarizing for the 128 crossings, 34 per cent of the cost was paid by the railroads, 32 per cent by the state and 34 per cent by Federal aid, almost an equal division by each.

In the second part of the summary, those reporting did not report separately the costborne by Federal aid, so the costs borne by the state and Federal aid are shown together. That summary covers 236 crossing separations or eliminations of which the railroads paid 50 per cent and the state and/or Federal aid paid the other 50 per cent of the cost. Combining all the data for 268 crossing separations reported, the railroads paid 46 per cent of the cost, the state and/or Federal aid paid 54 per cent. The total cost

of the 268 crossings is reported at $7,500,000, or an average cost per crossing separated of about $28,000.

Of course, it should be understood that this tabulation covers only crossing separation or eliminations on Federal Aid Highways and does not include crossings in towns of over 2500 population.

The recommedations of the Sub-Committee are:

"1. Authority to order grade crossing elimination, separations, or proper protection at grade crossings should be vested in the state commission or other state body having jurisdiction over railways, which should also determine and enforce proper division of cost between the railways and the public.

"2. The Federal Highway Act should be amended to provide that every elimination of a grade crossing of a railway with a Federal aid highway should be included in a Federal aid project and Federal aid should be applied to such crossing elimination to the extent of 50 per cent of the cost thereof.

"3. The cost of a grade crossing elimination in excess of the Federal aid allotment thereto should be apportioned between the state and/or subdivision thereof and the railway company on the basis of the conditions at such crossing, and of the benefits arising from such elimination."

The President:—I understand, Mr. Chairman, that this is submitted as information.

Mr. Frank Ringer:—All except the recommendations.

The President:—What action do you wish taken?

Mr. Hadley Baldwin:—It was the intent of the Committee that its recommendations be approved and referred to the Board of Direction for transmission to the American Railway Association. Maybe we are going too far for the Committee to recommend the transmission to the American Railway Association, but we feel that the convention should approve the recommendations of the Committee and the reference of the recommendations to the Board of Direction. I so move.

Mr. Frank Ringer:—I would like to say that it was the understanding of the Sub-Committee that the intent and practically the language of the Federal Highway Act sets aside 50 per cent of the cost of bridges of over 20 foot span and the word bridge has been interpreted to cover a grade crossing separation or elimination and we felt we were following the intent of the law.

Furthermore, we have not figures, but I am rather inclined to believe that the aggregate cost of the grade separations on Federal aid highways is a very small percentage of the total cost of such highways in the state, and I think that the Association can very well follow the intent of the law and go on record as favoring the same proportion of Federal aid to be applied to a grade separation as is applied to any other part of the highway in the state, which is according to the law, 50 per cent of the cost up to the limit of $15,000 per mile of highway.

The President:—Are there any other suggestions?

Mr. C. C. Westfall (Illinois Central):—I want to question Recommendation No. 1. It is recommended that the authority over grade crossing

elimination should be vested in the state commission or other state body having jurisdiction over railways.

It seems to me that would make it a cumbersome proposition in some states, as some states have highway commissions and in addition to that commission, a railroad commission. Those two commissions are made up of the same class of men, business men, and the highway commission has its engineers to make recommendations to it, and it decides as to whether or not a grade separation is necessary.

Then in this case it would have to prove to another commission of about the same standing that grade crossing elimination is necessary. It looks like a cumbersome procedure to have commissions of the same class pass upon these grade crossing matters.

We have found that the highway commissions when they exist in the states, are very fair men to deal with, and it is quite probable that the railroads will be able to get as good a proposition, as good an understanding from the highway commissions themselves as to satisfy them and then go before a railway commission. We have just finished trying to convince the people in one state that the highway commission was the proper body to handle such matters rather than the railroad commission. Highway commissions are dealing with these matters all the time. They keep in touch with public opinion towards the necessities and the division of costs probably more closely than the railroad commissions. It seems to me that the highway commission would better be the authority than the railway commission.

Mr. Frank Ringer:—I might say in reply to that, that the summary on page 704 with reference to the provisions of the states for determining division of costs, shows that the state commissions have the authority to determine the division of cost in twenty-four states now. The information does not disclose that the state highway commission in any state is clothed with such authority. It is the view of the Sub-Committee that the state commission or other body designated and empowered by the state to have charge of the affairs of the railways as between the railways and the public, should be clothed with authority and charged with the responsibility of determining proper division of costs of grade crossing separations and eliminations.

Mr. W. H. Kirkbride (Southern Pacific):—I wish to second Mr. Ford's amendment to the motion and wish to talk on it.

I believe we should eliminate this reference to 50 per cent. As it stands now, in many states the railroads secure nothing from the highway appropriation so far as Federal aid is concerned, due to the fact that when the highway commission, or engineers, set up their schedule of one-seventh of the entire mileage on which they want Federal aid, they deliberately eliminate the section that covers the grade separation. The result is that though your Federal engineer might be in sympathy with participating in the expense of this grade separation, as I understand it he is helpless, he cannot help you at all because it is not included in the schedule of requests from the highway engineers of the state.

Recognizing the fact that as it stands now we do not get anything, is it not better to try to bring this about by getting something—one-third? There are probably many state engineers who would be willing to contribute one-third on the basis that the Federal engineer contributes one-third and the railroad engineer put up his third.

I think it would be best to carry out the suggestion of the amendment, to make no reference to the 50 per cent. Neither do I wish to infer that we should make reference to one-third, but leave it as a just proportion to be determined as the facts of the case might develop.

With reference to the control of these problems, we usually have two public service corporations. You have a railroad commission that ultimately pass on these things when they are submitted to them, but you first have the highway commission to work out the problem and endeavor to have a clean case to present to the railroad commission. I, therefore, think it would be advisable to change No. 2 as suggested.

Mr. Hadley Baldwin:—I think both Mr. Ford and Mr. Kirkbride have somewhat missed the point of the second recommendation. They are talking to a point that is a phase of the matter that is covered in the third paragraph. The second paragraph is simply this: "The Federal Highway Act should be amended," the law should be changed, "to provided that every elimination of a grade crossing of a railway with a Federal aid highway should be included in a Federal aid project." That is all the second paragraph provides, and it is already fixed in the law that where the Federal aid goes, it goes 50 per cent up to a certain limit.

Mr. R. H. Ford:—I withdraw my remarks. Mr. Baldwin is correct. I did not notice that it was the recommendation that the law be changed. I withdraw what I had to say in respect of it.

Mr. Hadley Baldwin:—I think, also, Mr. Kirkbride, if I am not mistaken, the third recommendation touches the point you were discussing, does it not?

Mr. W. H. Kirkbride:—Possibly so.

The President:—Mr. Ford has withdrawn his motion. Do you consent, Mr. Kirkbride?

Mr. W. H. Kirkbride:—I do.

The President:—The question is on the approval of the recommendations on page 704 and referring them to the Board of Direction to be forwarded to the American Railway Association. Are you ready for the question?

Those in favor of the motion will say "aye"; opposed "no." The motion is carried.

Have you anything further, Mr. Baldwin?

Mr. Hadley Baldwin:—Nothing further.

The President:—Mr. Baldwin says he has nothing further at this time. The Committee is excused with the thanks of the Association for the excellent work it has done during the past year. (Applause.)

DISCUSSION ON STRESSES IN RAILROAD TRACK

(For Report, see pp. 925-926)

Dr. A. N. Talbot (University of Illinois) :—The Special Committee on Stresses in Railroad Track presents this year only a report of progress. Work has been continued, however, and it is expected that a report giving the results of the work for the last two years will be ready during the coming season.

The recent work has been directed to the rail joint. An effort is being made to determine the action of these joints in resisting or helping to resist the moments and stresses which come upon the track structure as the load passes over. This has been done with various types of joint. It is quite evident that the shape of the rail joint has a great deal to do with the way in which the joint behaves.

In connection with these tests, measurements have been made of the amount of the tensile stress in the track bolt, both as it is found in the track and as it was used in the laboratory tests. Tests will also be made to determine what change in the tension in the bolt occurs as the load passes over the joint. This information will help to decide what tension is desirable, and whether that tension should be different with different forms of rail joint.

It is, of course, apparent to all that the amount of the tension in the track bolt varies greatly along the same line of track. It is very easy to determine this without an instrument, in many cases, on good main line track. The bolt may have no tension in it, even though the general appearance may indicate the usual amount of tension.

A development has been made recently of an instrument which we have used in the laboratory and will use in the track to determine the amount of this tension as the load passes over it. This instrument takes the place of a track bolt. It is made of chrome-nickel steel built in an accurate fashion, a hole through the entire length of the bolt enables a rod to be inserted through the hole, and this is arranged with a dial at the end so that changes in the amount of tension can be determined quickly.

There are difficulties, of course, connected with this question of the tension in the track bolt. What we generally observe in our measurements is the average tension of the bolt. We have found, of course, that there may be enough bending strain in the bolt due to the nature of the bearing at the two ends to make the stresses at two sides of the bolt quite different. In fact, the stress on one side of the bolt may be twice as much as the average stress on the bolt.

In this investigation of the joints in the track the effort is being made to find what the purpose of the joint is. We have always assumed that the joint is for the purpose of making a girder, the same as the rail makes a girder. That is the intention in the design of most forms of joint.

Our measurements in the track have shown that the joint bar may take from a zero amount of bending moment to as much bending moment as is found in the full rail at points away from the point. This wide range has complicated our work greatly, and we are still engaged in a study to find what produces these conditions. That is not easy because conditions of ballast and other features of track have a good deal to do with it, and

sometimes what would seem to be a joint that should go down at once may stand up under good conditions of track for a considerable time.

The Committee, of course, will be glad to have suggestions concerning the problem that we are working on. It is hoped that the report, when it is printed, will bring out definite information that will give you an opportunity to discuss the question quite fully.

The President:—Gentlemen, you have heard Dr. Talbot's report. Have you any questions to ask him, or any suggestions to make?

Mr. L. J. F. Hughes (Chicago, Rock Island & Pacific):—I have a suggestion to offer to the Committee, and they may take it for what it is worth. Dr. Talbot mentioned something of the difficulty in measuring the stress and the device for measuring the stress in track bolts. The same difficulty is found in measuring stresses in rails, and in all the various ways in which it has been attempted to measure stress with the devices used by the Committee and other bodies.

In measuring the stress in rails the actual stress or strain is measured, as I understand it, and that measurement is recorded in certain ways. In some cases the movement of the needle has been recorded upon a smoked glass disc. Then there was the extensometer, an instrument developed by a Committee of this Association a number of years ago. Anyone who has had any experience in handling those instruments on the track realizes the difficulty of making a set-up where you can measure the stress in track with the trains and the traffic moving over it all the time.

Taking a hint or taking the idea from the development of the transverse fissure machine, it has occurred to me that it might be possible to measure the stress in rails and track and other appliances by an electrical method. I may be altogether wrong in the assumption, but I think it would be worth while to see if we could not find some relation between conductivity and stress. It is something that would have to be developed in the laboratory.

I have a vision of being able to measure or explore the interior of a rail by an electrical method while the rail is in track and being used and subjected to the regular traffic under regular conditions.

If this could be done, the ease with which measurements could be made is apparent. Your instruments could be at one side where they could be read with ease, while the measurements were actually being made. This idea is something I give to the Committee with the possibility of it being developed.

The idea is that we would have to have some of the laboratories in our schools have students or others make investigations and see if some relation can be established whereby we can make use of the electrical principle in measuring the stress.

The development of radio amplification has reached such a stage that the most minute indications can be detected and picked up and amplified, so that some record can be made of it, and I should like to see something attempted along this line within the next year.

The President:—Are there any other suggestions? If not, the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON WOOD PRESERVATION

(For Report, see pp. 707-748)

Mr. F. C. Shepherd (Boston & Maine):—The subjects assigned to the Committee on Wood Preservation are listed on page 707 of Bulletin 304. The reports are given in Appendices A to G on pages 707 to 748 in the same Bulletin. You will note on page 708, under Appendix A, we offer no revision to the Manual for this year. On page 709, a progress report is given on the definitions of terms used in wood preservation. There are a few minor corrections. The principal one is on page 709 under Creosote; the next to the last line should read "range lies above 200 deg. C.," instead of "about 200 deg. C."

On page 711, under Seasoning, Oil, the second line should read "above the boiling point" instead of "above the boiler point."

This report is offered as information and progress.

On page 712 is given the report upon Service Test Records for Treated Ties, including a table of the additional completed service tests reported by the Forest Products Laboratory, and a revision of the table of renewals per mile, including twenty-six railroads.

On page 716, Appendix D, there is a report on a recent inspection of long-time test pieces prepared by the Chemical Warfare Service, the Army and Navy, and other cooperators in connection with the marine piling investigations.

On page 726, Appendix E, is given a result of inspection tests last October of the Cleveland Test Section, relative to treatment with mixture of creosote and petroleum, and on page 738 a similar report on the mixture of zinc chloride and petroleum, both of these tests carrying tables indicating results in various methods.

On page 748, Appendix G, Effect of Preservative Treatment with Air-Seasoned Douglas Fir. No report is given other than one of progress.

Mr. President, this Committee report is one of information only and we ask that it be accepted and the subjects assigned for the following year.

The President:—All the Sub-Committee reports of this Committee are submitted as information. They wish to call your attention to the definitions of terms in wood preservation, shown on pages 709, 710, 711 and 712.

It has been suggested that you look over these definitions carefully at your leisure and if you find anything in them that you think should be changed, you should write to either the Secretary or the Chairman of the Committee.

The report of this Committee is now before you. The Committee would be glad to have your suggestions or criticisms. If there are none, the report of the Committee will be received as information, and the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON RECORDS AND ACCOUNTS

(For Report, see pp. 749-926)

Mr. J. H. Hande (Baltimore & Ohio) :—Aside from the recommendations for revision of the Manual, of which we have none to make this year, Committee XI has six reports, the first five of which are for information only.

These reports will be presented briefly by the Chairmen of the Sub-Committees and opportunity afforded for comments and discussion.

The first deals with an item of collaboration with Committee XXI—Economics of Railway Operation, Mr. H. E. Hale, Chairman.

Mr. H. E. Hale (Presidents' Conference Committee) :—The subject assigned to your Sub-Committee is "Continue study of methods for reporting proportional increases in expenditures resulting from increased use of physical property and also through increase of property investment, collaborating with Committee XXI—Economics of Railway Operation."

Committee XI has reviewed the report of Committee XXI—Economics of Railway Operation. The conclusions of the Committee and Committee XXI are on page 751. They have reviewed the report of Committee XXI, which is on pages 911 to 926, inclusive, of the 1925 Proceedings and adopted by the Association in March, 1925, for inclusion in the Manual.

In this report detailed instructions are given for compiling the data under the two methods proposed. Committee XI has collaborated with Committee XXI and that Committee is in accord with the views of Committee XI, that no special printed or ruled forms need be designed and recommended by Committee XI at this time, and that plain, unruled paper work sheets only are necessary in applying either method recommended.

This Committee recommends that the subject be discontinued. I might say it is not the character of information that is passed from one officer to another. It is only worked up once in a while, and no special forms are necessary for the working out of the formula, and your Committee sees no necessity of having any forms, and it so recommends.

I move that the recommendation of the Committee that no forms are necessary, be accepted.

The President:—You have heard Mr. Hale's motion, that the subject under Appendix B on page 751 be discontinued.

Is there any discussion? There seems to be no one who wishes to discuss the question.

(The motion was carried.)

Mr. J. H. Hande:—The next assignment is a similar one of collaboration with Committee XXI and Committee XXII and resulted in somewhat the same action. Mr. B. A. Bertenshaw, Chairman of the Sub-Committee, will present the report.

Mr. B. A. Bertenshaw (Cleveland, Cincinnati, Chicago & St. Louis) :—The assignment of this Committee is printed on page 752, Bulletin 304, and is as follows: "Develop units or methods for use in control of maintenance

expenditures from data taken from maintenance foremen's reports and used in preparing reports for the I.C.C., collaborating with Committee XXII—Economics of Railway Labor, and Committee XXI—Economics of Railway Operation."

Committee XI is of the opinion that the scope of its assignment is limited to the design of any form required in connection with the reports of Committee XXI and Committee XXII. Our Committee collaborated with these other two committees and reached an agreement that their reports require no specially designed forms; we therefore recommend that this subject be dropped.

The President:—If there is no objection, the recommendation of this Sub-Committee will be accepted.

Mr. J. H. Hande:—The next assignment is a very interesting one, "Report on the use made of aerial surveys and results obtained therefrom." Mr. G. R. Walsh, Chairman of the Committee, will present this report.

Mr. G. R. Walsh (Missouri Pacific):—The report of this Committee is on page 752 and includes a rather comprehensive bibliography. The report is offered as information.

The President:—The report appearing under Appendix D on the use made of aerial surveys and results obtained therefrom is offered as a progress report.

Are there any questions or suggestions, or any discussion? If there are none, it will be so received.

Mr. J. H. Hande:—Appendix E, or assignment No. 5, reads, "Collaborate with other committees in the preparation and design of forms pertinent to their work." Mr. C. K. Smith, Chairman of this Committee, is not here. This is presented as a preliminary report as information.

I would like to point out that Committee XI has taken the opportunity, under the assignment, to review its field of action to see what forms have been designed and to try to find what other forms may be necessary. The list of forms as we have found them printed in the Manual appear on page 761 of Bulletin 304. Our effort is to make that list as inclusive as possible of all the forms that are used in the routine operations of a railroad, and we invite suggestions of such additions to that list as may be considered necessary.

That report is submitted as information.

The President:—You have heard the report in collaboration with other committees in the preparation and design of forms pertinent to their work. You notice the Chairman of the Committee requests that you furnish him with any suggestions as to additions or deletions from this list of forms. I assume you will do so during the ensuing year so that his report may be brought more nearly up to date by the time of the next annual meeting.

Mr. J. H. Hande:—We are all familiar with the action of the Interstate Commerce Commission in conjunction with railway accounting officers, in revision of the accounting classifications. This Committee is not actively participating in any of that work, but we are interested in watching what is going on, and we want to keep the Association informed. Mr. Alfred Hol-

mead has investigated and written up a comprehensive report, and I would like him to introduce that to the Association.

Mr. Alfred Holmead (Presidents' Conference Committee):—The assignment No. 6 to Committee XI called for a report of the progress made in the matter of revisions in the Interstate Commerce Commission classifications of accounts. In response to this assignment, there is submitted a statement, beginning at page 766 of Bulletin 304, designated Appendix F of the report of this Committee, which outlines the work that has thus far been done in the way of drafting revised classifications.

This statement indicates the general character of the changes proposed by the Bureau of Accounts of the Interstate Commerce Commission, and also by the Railway Accounting Officers' Association. As you gentlemen know, those two agencies are co-operating in the work of preparing the contemplated revisions. Our report upon this matter is devoid of any discussion or comment by this Committee.

We ask that you receive the statement as information, and that the assignment be continued.

Mr. J. H. Hande:—There is one thing that may be of interest to the membership, and that is the alternate classification recommended by the Railway Accounting Officers, the so-called three-account classification beginning on page 786. That has received consideration of the Bureau of Accounts of the Commission, and I think the Association would be interested in reviewing that to see what the ideas of the accounting officers are. The fundamental point, I think, is that the accounting officers consider that they should account for the dollars and book the projects in as simple a way as possible, and that if there is any statistical work to be done, it should be done by the valuation accountants or Valuation Bureau and avoid the necessity of so many adjustments between primary accounts on the books. The reasoning is sound, the question, of course, being how far it will get in the negotiations now going on.

Mr. H. M. Stout (Northern Pacific):—I wish to comment briefly upon this section of the Committee's report, which impresses me as a very excellent one. They have brought together a great deal of information that is available only in scattered locations. The Chairman of the Committee has referred to the printing of the Railway Accounting Officers' Association's recommended classification. He did not mention another proposed classification which is under discussion. Perhaps that was brought to the attention of the public and to the Commission after this Committee had prepared its report, and was not available at that time. If that is a fact, I would suppose and hope that the Committee would make that suggestion available to the Association in its next report.

Mr. J. H. Hande:—We brought this up to November 9, the date of the opening of the depreciation hearing. It will be brought forward from that date next year.

Mr. H. M. Stout:—I did not refer to the depreciation hearing, but the proposed cost accounting system.

Mr. J. H. Hande:—We brought it to that. That seemed to be a good date to stop before we sent in the report.

The President:—Are there any further suggestions, gentlemen? If not, the report on Revision of I.C.C. Classification of Accounts will be received as information and the subject continued for next year's work.

Mr. J. H. Hande:—Appendix G covers plans, methods and forms for gathering and recording data for keeping up to date the physical and valuation records of the property of railways. This is presented for inclusion in the Manual. Consideration must be given to the fact that changes are taking place and that this represents our recommendation at the time this went to the press.

Mr. Haire will present the report.

Mr. C. C. Haire (Illinois Central):—The Sub-Committee's report is on page 851. The report consists of what has been presented heretofore as progress reports, together with certain additional information. It is now before the Association for the first time.

In presenting this report the Committee wants to call attention, as Mr. Hande has said, to the possible changes now being considered by the Interstate Commerce Commission in the requirements of Valuation Order No. 3. These changes have not yet taken a mandatory form and they may or may not be a requirement. The Committee can only submit its report on the basis of the present requirements and what it deems good practice.

We also wish to call attention that the Committee's report applies not only to this subject, the physical and valuation records, but also must be considered as partly the basic Investment and Depreciation accounting records.

As may be observed, the report is divided into seven sections, the first of which is "Definition of Terms." The Committee submits 71 definitions that are generally used in accounting for capital expenditures and valuation. Some of these definitions have been before you in previous progress reports and some of them have just been added.

The second section is "Organization for Collecting, Compiling, Recording and Filing." This subject has been presented heretofore in progress reports. It is now offered for final adoption.

The third section is "Forms for Recording Changes in Physical Property." The Committee submits 24 records or forms in this section of the report. We feel that these forms are basic fundamental records and underlying records to be used in recording property changes. They are really auxiliary or supporting records to Valuation Order No. 3.

Fourth section, "Forms for Analysis of Expenditures in Comparison with Actual Changes in Physical Properties." These forms are principally for use in the accounting analysis and in building up the basic records.

Fifth section of the report, "Mandatory Forms Required by Federal Regulations." These forms are the usual Valuation Order No. 3 forms which the Committee has modified somewhat and which we consider as good practice.

The sixth section, "List of Units of Railway Property." This list was published several years ago and I think everybody is familiar with it, but is

one of the subjects that probably should be held in abeyance because of the possible changes that the Interstate Commerce Commission will make in the list of units.

Right here I should like to say if Mr. H. L. Ripley, of the New Haven, is in the audience, probably he could give you some information on that subject. As I understand, it is a live subject that is being discussed daily with the Bureau of Valuation, and I would appreciate any suggestions as to whether these units should be dropped or whether they should be included in the Manual.

The seventh section of the report, "Recommended Practice to Follow in Reporting the Construction Cost and Physical Characteristics of a New Line or Extension." This is a new subject and is in the nature of specifications for building up a report of the cost of construction of a large project.

This concludes the Committee's report, and I move that all the sections I have just mentioned, with the exception of Section 6, be approved for inclusion in the Manual.

The President:—It has been moved and seconded that the Sub-Committee's report on Plans, Methods and Forms for Gathering and Recording Data for keeping up to date the Physical and Valuation Records of the Property of Railways, contained between pages 851 and 923, except Section 6, be approved by the Association for publication in the Manual.

If Mr. Ripley is in the audience, we would like to hear from him.

Mr. H. L. Ripley (New York, New Haven & Hartford):—Mr. President, this Committee is to be commended on the tremendous amount of work it has done. They have given us 175 pages in this report. They have recommended for inclusion in the Manual many paragraphs.

Unfortunately for me, this particular volume came to me late and I was away, so that I did not get a chance to read it even until on my way out here, and I am not prepared to discuss it in detail. I do not know how much of this is new. I have been able to read it only hurriedly and I wonder whether it is desirable or even proper at this time to accept and publish in the Manual as recommended practice these conclusions when, if I understand it, they are coming before this Association for the first time today and so little time has been given to considering them.

You gentlemen all probably know that the executives formed a conference body called the Presidents' Conference Committee, and those executives have designated certain general and special committees to consider this subject of valuation. In this matter we have only the power of persuasion. The work is intimately associated with government bodies and government authorities who have final say in the matter.

It may be that this Committee, the Sub-Committee of which was made up very largely of Valuation Engineers, has nothing in those conclusions that is contrary to the requirements of the Commission, which requirements have been issued as formal orders.

The one thing I saw in the report of the Committee that seemed to me definitely objectionable was the promulgation of this list of units, and the inclusion of those units in the Manual.

This list of units was prepared by the old Joint Conference Committee on Order No. 3 in 1921. I think it was in December, 1927, the Director of the Bureau of Valuation asked that the Joint Conference Committee, consisting of both Bureau of Valuation and carrier members, be reconvened to study methods and plans for bringing the valuations down to date, and the first subject assigned to the committee was this matter of the list of units.

The old list was revised and sent out in tentative form for comments and constructive suggestions. Those suggestions have been returned to the Joint Conference Committee; have again been reviewed (and when I say reviewed I mean the Committee has put some eighteen or twenty days on them) and they have been again sent out to the carriers, the probability being they will be included in an order of the Commission. So that this 1921 list is already obsolete.

Mr. Haire, I believe your recommendation is that this list be not included in the Manual?

Mr. C. C. Haire:—That is right.

Mr. H. L. Ripley:—That would remove that objection; probably every carrier by this time has the new list of units.

Much in this report is, I believe, very commendable, particularly the recommendation that this Committee has made that some definite organization be given responsibility for the work, and the old Order No. 3 committee of the Presidents' Conference Committee has repeatedly emphasized that, and even gone further; we have recommended very definitely that it be made the responsibility of some one man having commensurate authority. Because I am so unfamiliar with the thing, I do not feel that I should take up more time of this body in attempting to discuss the matter. I do feel, as I said before, that unless this Committee is very sure that none of these conclusions are in conflict with what is required, and what is likely to be required in the near future, it may be undesirable to print them in the Manual as recommended practice, although the information is exceedingly valuable, not only to the carriers in general, but to the Joint Conference Committee, as information.

Past-President J. L. Campbell:—Mr. President, the Committee is to be commended upon the large amount of excellent work it has done, and this very good report. However, I want to second all that Mr. Ripley has just said. The subject of valuation is largely dealt with in this report of the Committee, and there is much of valuation, at the present time, in a state of flux, and in view of the fact that these recommendations come from the Committee at the end of only one year's study and report, I believe it would be highly undesirable to include the recommendations in our Manual at this time.

Mr. H. C. Crowell (Pennsylvania):—The work of this Committee has always been so commendable (and it has, in my opinion, always deserved the thanks of this convention) that I hesitate to make this criticism. While all of this material is no doubt of great interest and deserves a place in the Proceedings, which it will get, it seems to me that it may be briefed or

abstracted very materially before it goes into the Manual, whether it be this year or next year.

You will find that there is a total of 74 pages of printed matter in addition to two folded inserts, making a grand total of 76 pages. Of these 76 pages, 33 pages are forms, and some of the forms are very simple indeed. It seems to me that they could be described for the purpose of the Manual in a single sentence. For example, one of these forms is nothing more nor less than a piece of cross-section paper ruled ten by ten to the inch. If we are going to keep the Manual down to any reasonable size, this will have to be abstracted, reduced in bulk very much, or else we will be out of balance. We will lose our sense of proportion. I think that when the Committee comes forward next year with its report, providing it agrees to follow what Mr. Campbell and Mr. Ripley have suggested, it should also bring in for the Manual a report in abstracted form with most of the forms either described or, if printed, merely column headings rather than a whole page of forms. Various little tricks of that sort can be worked out to cut down the volume.

So far as the meat of the thing is concerned, I am perfectly willing to leave it to Mr. Haire and his able assistants in the Valuation Department, because I have full confidence that everything in this report is 100 per cent correct.

Mr. W. H. Woodbury (Duluth & Iron Range):—I should like to second everything that has been said on the floor. I heartily agree with all the comments made, and I should like to suggest to the Committee that the most graceful way to handle it is to withdraw the motion to have it printed in the Manual, and submit it as information. I agree it is good information, although there are things in it I should like to see changed. I should like to have an opportunity to point out a great many changes I think should be made in some of these forms. I believe that in view of the fact it has only been submitted the first time and it is so voluminous, it is going to take more room than we can spare in the Manual, and in view of the other criticisms the gentlemen have made, I would like to request the Committee to reconsider and offer it as information.

Mr. C. C. Haire:—Mr. Chairman, the Committee is willing to withdraw the motion. We were rather reluctant to submit a report of this kind for inclusion in the Manual, in view of these pending changes, and considering what has been said, the Committee will gladly withdraw the motion.

Mr. H. L. Ripley:—Mr. President, I want to thank Mr. Haire for that, and I will agree, speaking for the Order No. 3 committee, to make a careful review of this report and give you any suggestions that we may have because of our more intimate contact with the Government men who have this matter in hand, by letter in ample time so that you may have the information, for whatever it may be worth, to work upon next year.

The President:—Sub-Division 7 of this Committee's report will be received as information.

Mr. Chairman, have you anything further?

Mr. J. H. Hande:—Our Appendix H, assignment No. 8, deals with the methods and forms for handling depreciation, which matter, as we all know, is in process of hearing at Washington. It will be resumed this month. The subject has been assigned again to this Committee. All that we can do under the circumstances is to wait until a definite ruling comes out and go to work on whatever form the order takes. I simply mention that. It is shown in here as being dropped for this current year. It will be taken up again next year.

The President:—If there are no objections, the further study of Depreciation Order No. 15100 will be deferred until some definite action is taken by the Interstate Commerce Commission.

This Committee, as has been well said by several speakers in the audience, has brought to you a very large amount of excellent work this year. Whenever I think of the work being done by the Committee on Records and Accounts, and particularly at the present time with so much involved in valuation and depreciation accounting, I am inclined to think it takes a man with considerable courage to take a position as a member of this Committee.

The Committee is to be congratulated upon the excellent work it has done, and I wish to assure the members they have the thanks of the Association. (Applause.)

DISCUSSION ON BUILDINGS

(For Report, see pp. 927-965)

(Vice-President Louis Yager in the Chair.)

Mr. Frank R. Judd (Illinois Central) :—The various subjects assigned to the Committee have been listed under various appendices, commencing with Revision of the Manual, listed under Appendix A. This is the only subject that is recommended for inclusion in the Manual this year.

The revision refers to the specification for structural steel for railway buildings which was adopted last year. There are two clauses, namely 12 and 16, of that specification which the Committee wishes to revise, as shown on page 928 of the Bulletin.

Vice-President Yager :—It has been moved and seconded that the revision of Manual given in Appendix A, paragraphs 12 and 16, be adopted for inclusion in the Manual. Any discussion?

(The motion was carried.)

Mr. Frank R. Judd :—The second subject, Study and Report on Specifications for Concrete used in Railway Buildings, is shown under Appendix B and is submitted as a progress report with the intention that the subject be reassigned next year.

Vice-President Yager :—Are there any comments or suggestions? If not, it will be so received.

Mr. Frank R. Judd :—Subject No. 3, Study and Report on Artificial Lighting for Railway Buildings, Appendix C, page 929. This subject is submitted as information and also as a final report. The idea is that with the constant changes in electric lighting fixtures, it is undesirable to make a recommendation for the Manual which probably would be subject to change constantly and we, therefore, submit this as information to be published in the Proceedings.

Mr. A. G. Dorland (Elgin, Joliet & Eastern) :—On page 929 of Bulletin 304, Appendix C, about the middle of the third paragraph, we find the following: "The proper illumination of shops will insure much greater efficiency and reduce accidents from 20 to 25 per cent. This means direct money saving to the railways."

I would move that we eliminate the last sentence reading: "This means direct money saving to the railways."

We should think of safety as a safety item and not put it on a dollars-and-cents basis; if anyone wishes to think of it that way they can read between the lines, but to me at least this sentence is offensive and I think that it should not go into our records.

Mr. Frank R. Judd :—The Committee accepts the suggestion.

Mr. W. H. Woodbury (Duluth & Iron Range) :—I would like to suggest right along that same line that the words after the word "accidents" be eliminated. It reduces accidents. That is all that is necessary, whether 20 per cent or 50 per cent. I would prefer to see that out.

Mr. Frank R. Judd :—The Committee will be glad to accept that suggestion also.

Vice-President Yager :—If there are no further suggestions, the report will be received as information and printed in the Proceedings.

Mr. Frank R. Judd:—The next subject is the study of methods for improving lighting, ventilation and convenient arrangement of railway structures, used in whole or in part for office purposes. Mr. A. L. Sparks is Chairman of this Sub-Committee and I will call on him to present this report.

Mr. A. L. Sparks (Missouri-Kansas-Texas):—This subject embraces three items, the first two of which have been covered by other Sub-Committees so that the work overlaps.

(1) Study of method for improved lighting is included in the work of Sub-Committee 3, as previously reported.

(2) The ventilation of buildings was included in a report of the Sub-Committee in 1925, and reported in Volume 26 of the Proceedings, page 466.

(3) Convenient arrangement of railway structures used in whole or in part for office purposes.

There is such a divergency in the grouping of offices on account of the different operating requirements on the various railroads that it is not thought expedient for this Committee to offer any suggestions for standard arrangement of offices. It is therefore recommended that this subject be discontinued.

Vice-President Yager:—Are there any comments? If not, the Board of Direction will consider the suggestions of the Committee.

Mr. Frank R. Judd:—The next subject is a study of rules and regulations for employees of the Buildings Department, collaborating with Committee XII—Rules and Organization. There has been no progress made on this subject, and it is the request of the Committee that it be reassigned for next year.

Vice-President Yager:—Such action will be taken.

Mr. Frank R. Judd:—Under Appendix F you will find the report on study of Design and Construction of Water Station Buildings, collaborating with Committee XIII—Water Service. This report will be presented by Mr. Hugo Filippi.

Mr. Hugo Filippi (William Grace Company):—As stated in the subject-matter, our report this year is predicated on the report made last year by the Water Service Sub-Committee. We have endeavored in general to outline the different types of buildings and to give the general requirements of these buildings. We have followed that by general detailed instructions.

In our study so far we find a very wide variation in the standards used on the several railroads of the country, and if this subject is reassigned to the Committee it is the purpose of your Sub-Committee to send out a questionnaire to the railroads and from that endeavor to set up standards or to make definite recommendations. The report is offered to you merely as information and as a progress report on the subject.

Vice-President Yager:—Are there any suggestions? If not, it is the purpose of the Board to correlate this work between the two committees.

Mr. F. R. Judd:—Subject 7 is study of permissible grades for ramps in railway buildings; collaborating with Committee XIV—Yards and Terminals.

This subject was submitted last year and was reassigned to the Committee on account of the difference in conclusions arrived at by this Com-

mittee and the report on the same subject made by the Committee on Yards and Terminals. The Committee on Yards and Terminals report, I believe, has been accepted for the Manual, and our report is therefore submitted as information. The conclusions arrived at are shown in the summary on page 938, and the Committee on Yards and Terminals assure us that they are in accord with this summary.

Vice-President Yager:—In view of the previous action taken on another committee's report having the same subject-matter in hand, this report will be received as information.

Mr. Frank R. Judd:—Subject 8 is the report on Specifications for Buildings for Railway Purposes.

This is a subject that has been assigned to the Committee from year to year, and quite a number of specifications have been submitted and accepted for publication in the Manual. This year the specifications submitted by this Committee have to do with driveway pavings for teamways and driveways adjacent to passenger stations and freight houses. Under this heading the Committee has submitted this year specifications for concrete paving, wood block paving, wood block floors, native sheet asphalt paving, asphalt block paving, asphalt block floors, macadam and asphalt macadam. These are submitted as tentative specifications, the idea being that they should be used this year by the Association so that the Committee can have the benefit of any criticisms the various railroads may wish to offer on account of the use of these specifications.

Mr. J. C. Irwin (Boston & Albany):—I believe at this time attention should be called to the fact that in each one of these specifications there are two paragraphs which properly belong in the contract forms and therefore should not be included in the specifications.

The Committee on Uniform General Contract Forms has consistently avoided any specification items, and I think it has been agreed that the work of the Uniform General Contract Forms Committee should include such items as No. 1, General, and the last one, General Conditions. The first is on page 939 and the second on page 945, and similar ones occur in each of the following specifications. Therefore, I should like to call this to the attention of the Committee and ask that those two sections be withdrawn from the specifications because they are covered in contract forms which will be used with the specifications.

Vice-President Yager:—The Committee is very glad to receive that suggestion.

Mr. Hadley Baldwin (Cleveland, Cincinnati, Chicago & St. Louis):—In reading over these specifications it struck me that there is a great deal of repetition. So many of the clauses in each different case are almost identical that for the purposes of recommended practice it seems to me the Committee could combine these forms and take up much less space in the Manual and at the same time make them cover the ground.

Mr. Frank R. Judd:—With regard to the first question brought up, these two clauses have been already accepted by the convention in about twenty other specifications and have been accepted for publication in the Manual, so

to eliminate them from these particular specifications that are submitted this year will cause some complications and require the revision of the previously accepted specifications.

Mr. J. C. Irwin:—I might say that each year the subject of the revision of the Manual has come up, and Committee XX has co-operated with other committees and has eliminated from the Manual all those things which seem to conflict with the contract forms. This matter was brought up at two or three of the meetings which the chairmen of the committees held after the convention each year, and I understood that the Committee was instructed to omit certain specifications or items covered by the contract form. If these have been included by the convention I am inclined to believe it is an inadvertency.

Mr. Hadley Baldwin:—If these provisions are in conflict with the general contract form, there is a point to objection to their being included, but if they are consistent with the contract, I see an advantage in having them in the specifications, because of the information to the bidders that is provided.

Vice-President Yager:—The matter discussed is one which is subject to revision at any time and one for the development of uniformity in our Manual practice, and it will be reviewed later by the appropriate committees with the proper collaboration as outlined in the assignments.

Before we close that matter, the Chairman would like to make a few additional remarks on the subject.

Mr. Frank R. Judd:—The Committee has considered the question of repetition in these specifications from time to time and has tried to boil each specification down to what is absolutely necessary to make it complete, but it was not thought advisable to constantly refer from one specification to another. We can do that, but to do it would, in our judgment, spoil the specification itself. It would make it too difficult for a party preparing a specification for some specific job to constantly have to refer to a large number of other specifications. It would make it very difficult for the inspector on the job to keep up with the contractor, and for that reason we have aimed to make the specifications complete on each subject.

Mr. J. C. Irwin:—I do not want to prolong this discussion, but I judge the specifications are not used independently of any contract form, and if you are trying to make a contract out of your specifications, there are a great many other sections that should be included.

I merely bring out the point that where the contract form and specification form are combined into a contract, very properly those would be part of the agreement in the contract portion and can be left out of the specification portion.

Vice-President Yager:—Anything further? If not, this report will be received as information with the understanding that any members who have anything to contribute in the way of suggestions will make them to the Committee in time for presentation in the final recommendations.

The Committee is excused with the thanks of the Association. (Applause.)

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